



## Foundation Investigation and Design Report

*Temporary Protection Systems at Bridge Site Nos. 37-819, 37-822 and 37-827,  
Structure Rehabilitation at Highway 401 / Highway 427, City of Toronto, Ontario,  
G.W.P. 2032-11-00*

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# PART A

**FOUNDATION INVESTIGATION REPORT  
TEMPORARY PROTECTION SYSTEMS AT BRIDGE SITE NOS. 37-819, 37-822  
AND 37-827  
STRUCTURE REHABILITATION AT HIGHWAY 401 / HIGHWAY 427  
CITY OF TORONTO, ONTARIO  
G.W.P. 2032-11-00**

## 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed rehabilitation of the existing structures listed below.

- Site No. 37-819 (Bridge 25): Eglinton Avenue East - Highway 401 West Collector Ramp over Highway 401
- Site No. 37-822/1&2 (Bridge 29): Renforth Drive N/S over Highway 401
- Site No. 37-827 (Bridge 70): Eglinton Avenue East - Highway 427 North Ramp over Highway 401

All sites are located within the Highway 401 / Highway 427 Interchange as shown on the Key Plan on Drawings 1 and 2.

This report summarizes the foundation investigation carried out to support the rehabilitation of the existing Highway 401 Underpass structures at the three sites identified above. The Terms of Reference for the foundation engineering services are outlined Golder's change request letter dated June 1, 2018 which forms part of the Consultant's Assignment for the Structure Rehabilitation at Highway 401/Highway 427, Assignment No. 2015-E-0026.

## 2.0 SITE DESCRIPTION

Site Nos. 37-819 and 37-827 are located about 1.6 km west of the intersection of Martin Grove Road and Eglinton Avenue West, with Site No. 37-827 located about 85 m north of Site No. 37-819. These structures are bordered to the north and west by industrial areas including the Molson Brewery which is about 100 m to 200 m north of the sites. Residential areas are present to the east and south of the sites. The road surface at the two structures is between approximately Elevation 155.5 m and 158.0 m and the Highway 401 grade is about Elevation 151 m. Based on the design drawings, Highway 401 appears to be constructed in cut and the bridge approach embankments consist of partial cut and fill placement.

Site No. 37-822/1&2 (the Renforth Drive Underpass), is located approximately 800 m west of Site Nos. 37-827 and 37-819. The Renforth Drive underpass is bordered by industrial/commercial lands (including the Toronto Pearson International Airport) to the north and commercial land / residential housing to the south. The Renforth Drive road grade is at approximately Elevation 163 m and the surrounding area is at approximately the same elevation. Highway 401 appears to have been constructed primarily in cut and the highway surface is at about Elevation 156 m.

## 3.0 INVESTIGATION PROCEDURES

The field work for the current investigation at Site No. 37-819, Site No. 37-827 and Site No. 37-822/1&2 was carried out on September 10 to 12, and December 2 and 16, 2018 during which time six boreholes (designated as Boreholes TP-01 to TP-06) were advanced at the sites.

Boreholes TP-01 and TP-02 were advanced within the approaches of Site No. 37-827 (Bridge 70), Boreholes TP-03 and TP-04 were advanced within the approaches of Site No. 37-819 (Bridge 25), and Boreholes TP-05 and TP-

06 were advanced within the approaches of Site No. 37-822/1&2 (Bridge 29). The approximate locations of the boreholes are shown on Drawings 1 and 2.

All completed boreholes were advanced using a CME-55 truck mount drill rig, both supplied and operated by Geo-Environmental Drilling Ltd. of Milton, Ontario. Boreholes TP-01 to TP-04 were advanced using 178 mm outer diameter hollow-stem augers, while Boreholes TP-05 and TP-06 were advanced using 152 mm outer diameter hollow-stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)<sup>1</sup>

Boreholes TP-01 and TP-02 were advanced on the east and west approaches of Site No. 37-827 to depths of 9.6 m and 9.2 m below the roadway surface, respectively. Boreholes TP-03 and TP-04 were advanced on the east and west approaches of Site No. 37-819 to a depth of 9.2 m below the roadway surface. Boreholes TP-05 and TP-06 were advanced on the south and north approaches of Site No. 37-822/1&2 to a depth of 9.4 m and 9.3 m, respectively, below the roadway surface. Traffic protection consisted of single lane closures, consistent with MTO Book 7 requirements.

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. All boreholes were backfilled and sealed at the roadway surface with cold patch asphalt upon completion, in accordance with Ontario Regulation 903, Wells (as amended).

The field work was monitored on a full-time basis by a member of Golder's technical staff who located the boreholes in the field relative to on site features, directed the sampling and in situ testing operations, logged the boreholes and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further visual review and geotechnical laboratory testing on selected samples, consisting of natural moisture content, Atterberg limits and grain size distribution conducted in accordance with MTO and / or ASTM Standards as applicable.

The borehole locations provided on the Record of Borehole sheets and shown on Drawings 1 and 2 are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, including geographic (Latitude / Longitude) coordinates, the ground surface elevations and borehole drilled depths are summarized below.

Borehole No.	MTM NAD83 (Geographic)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude)	Easting (m) (Longitude)		
TP-01	4,836,948.9 (43.672466)	298,282.7 (-79.580825)	155.5	9.6
TP-02	4,836,903.0 (43.672051)	298,053.8 (-79.583663)	158.0	9.2
TP-03	4,836,826.9 (43.671367)	298,116.4 (-79.582886)	157.3	9.2

<sup>1</sup> ASTM D1586 – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.



Borehole No.	MTM NAD83 (Geographic)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude)	Easting (m) (Longitude)		
TP-04	4,836,805.9 (43.671176)	297,906.1 (-79.585494)	157.8	9.2
TP-05	4,836,436.2 (43.667844)	297,491.7 (-79.590627)	161.7	9.4
TP-06	4,836,634.6 (43.669629)	297,406.2 (-79.591690)	161.4	9.3

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

This section of Highway 401 is located within the Till Plains of the Peel Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)<sup>2</sup>.

The Peel Plain physiographic region covers the central portions of the Regional Municipalities of York, Peel and Halton. The general topography of this region consists of level to gently rolling terrain, sloping gradually southward toward Lake Ontario. A surficial till sheet, which generally follows the surface topography, is present throughout much of this area. The till, which is mapped in this area as the Halton Till, typically consists of clayey silt to silty clay, with occasional sand to silt zones. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay. The study area, in the western portion of the Peel Plain, is underlain by grey shale of the Georgian Bay Formation.

### 4.2 General Overview of Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes of the current investigation, and the results of the in situ and laboratory tests are provided on the Record of Borehole Sheets in Appendix A. The results of the in-situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4 are uncorrected. The results of the geotechnical laboratory testing on soil samples are presented on the laboratory test figures in Appendix B.

The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected, however, the factual data presented on the borehole records governs any interpretation of the site conditions.

<sup>2</sup>Chapman, L.J. and Putnam, D.F. 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P. 2715, Scale 1:600,000.

## 4.2.1 Site No. 37-827 (Bridge 70) – Boreholes TP-01 and TP-02

In general, the subsurface conditions at this site consist of asphalt and concrete associated with the Highway 401 pavement structure, underlain by fill. The fill material is underlain by interlayered deposits of sandy silt to sand and sandy clayey silt to silty clay (till).

### 4.2.1.1 Asphalt

An approximately 90 mm and 80 mm thick layer of asphalt pavement was encountered at ground surface in Boreholes TP-01 and TP-02, respectively.

### 4.2.1.2 Concrete

An approximately 220 mm and 150 mm thick layer of concrete was encountered underlying the asphalt pavement in Boreholes TP-01 and TP-02, respectively.

### 4.2.1.3 Fill

A 4.2 m and 2.0 m thick layer of sandy clayey silt fill material was encountered underlying the concrete in Boreholes TP-01 and TP-02, respectively. The base of the fill layer extends to Elevations 151.0 m and 155.8 m in Boreholes TP-01 and TP-02, respectively. Cobbles / obstructions are inferred to be present within the fill layer as augers were grinding at a depth of about 1.5 m in Borehole TP-02 during the drilling investigation.

The Standard Penetration Test (SPT) “N”-values measured within the fill layer range from 12 blows to 29 blows per 0.3 m of penetration, with one discrete value of 61 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

A grain size distribution was carried out on one sample of the sandy clayey silt fill and the results are shown on Figure B1 in Appendix B. An Atterberg limits test was carried out on the sandy clayey silt fill and measured a liquid limit of 27 per cent, a plastic limit of 15 per cent, and corresponding plasticity index of 11 per cent. These results, which are plotted on a plasticity chart on Figure B2 in Appendix B, indicate the fill consists of clayey silt of low plasticity. The natural water content measured on three samples of the sandy clayey silt fill range from 11 per cent to 16 per cent.

### 4.2.1.4 Sandy Clayey Silt to Silty Clay

A sandy clayey silt deposit was encountered underlying the fill layer Borehole TP-01, and a sandy silty clay layer was encountered within the sandy deposit (described in Section 4.2.1.5 below) in Borehole TP-02. The deposit was 2.7 m thick in TP-1 and about 0.3 m thick in TP-2. The clayey layer contained trace to some gravel.

The SPT “N”-values measured within the sandy clayey silt to sandy silty clay range between 15 blows and 63 blows per 0.3 m of penetration suggesting a stiff to hard consistency.

A grain size distribution was carried out on one sample of the deposit and the results are shown on Figure B3 in Appendix B. Atterberg limits testing was carried out a sample of the deposit and measured a liquid limit of 24 per cent, plastic limit of 14 per cent, and corresponding plasticity index of 10 per cent. The results, which are plotted on a plasticity chart on Figure B4 in Appendix B, indicate that the deposit consists of clayey silt of low plasticity. The natural water content measured on a selected sample of the deposit is 11 per cent.

#### 4.2.1.5 Sand and Silt / Sandy Silt to Silty Sand

A deposit of sand to sand and silt was encountered underlying the sandy clayey silt deposit in Borehole TP-01, and underlying the fill layer in Borehole TP-02. Interlayers of sandy silt to silty sand were encountered below the sandy silty clay layer in TP-2. A summary of the sandy and silty layers encountered in the boreholes is provided below.

Borehole Number	Depth to Top of Layer (m)	Top of Layer Elevation (m)	Thickness (m)	Description
TP-01	7.2	148.3	1.3	Sand and Silt
TP-02	2.2	155.8	0.5	Sand
	3.0	155.0	0.7	Sandy Silt
	3.7	154.3	1.9	Silty Sand

Cobbles are inferred to be present within the sand and silt deposits as augers were grinding within this layer at depths between about 2.4 m and 2.7 m and 5.2 to 5.8 m in Borehole TP-02, and at about 7.9 m in TP-1.

The SPT “N”-values measured within the sandy and silty deposits range between 34 blows per 0.3 m of penetration and 100 blows for 0.23 m of penetration, indicating a dense to very dense level of compactness.

Grain size distributions were carried out on three samples of the deposit and the results are shown on Figure B5 in Appendix B. The natural water content measured on selected samples of the sandy silt to sand deposit range between 7 per cent and 10 per cent.

#### 4.2.1.6 Silty Clay (Till)

A silty clay (glacial till) deposit was encountered underlying the sand and silt layer in Borehole TP-01, and below the silty sand layer in Borehole TP-02. Both boreholes were terminated within the silty clay (till) deposit after penetrating it for about 1.1 m and 3.6 m in TP-01 and TP-02 respectively. The silty clay till deposit is well graded and contains shale fragments / cobbles throughout. Auger grinding was encountered from 7.3 m to 7.6 m and 8.0 m to 9.0 m in TP-02.

The SPT “N”-values measured within the silty clay till range between 32 blows per 0.3 m of penetration and 100 blows per 0.07 m of penetration suggesting a hard consistency.

Atterberg limits testing was carried out a sample of the deposit and measured a liquid limit of 42 per cent, plastic limit of 24 per cent, and corresponding plasticity index of 18 per cent. The results, which are plotted on a plasticity chart on Figure B4 in Appendix B, indicate that the deposit consists of silty clay of medium plasticity. The natural water content measured on a selected sample of the deposit is 14 per cent.

#### 4.2.1.7 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations. The groundwater level recorded in the open boreholes, if present, are provided on the borehole records in Appendix A and are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
TP-01	155.5	Dry	-	September 11, 2018	Open borehole (borehole caved to 8.1m)
TP-02	158.0	6.7	151.3	September 12, 2018	Open borehole (borehole caved to 8.2m)

The groundwater level observations at this site are not considered to represent long-term stabilized groundwater levels. Groundwater levels will be subject to seasonal fluctuations and precipitation events; the water levels should be expected to be higher during the spring season or during and following periods of heavy precipitation.

#### 4.2.2 Site No. 37-819 (Bridge 25) – Boreholes TP-03 and TP-04

In general, the subsurface conditions at this site consist of asphalt and concrete associated with the highway ramp pavement structure, underlain by fill. The fill material is underlain by a sand and gravel deposit that is further underlain by a silty clay till deposit. Weathered shale bedrock was encountered underlying the silty clay till deposit.

##### 4.2.2.1 Asphalt

An approximately 90 mm and 100 mm thick asphalt pavement was encountered at ground surface in Boreholes TP-03 and TP-04, respectively.

##### 4.2.2.2 Concrete

An approximately 230 mm thick layer of concrete was encountered immediately below the asphalt pavement in Boreholes TP-03 and TP-04.

##### 4.2.2.3 Fill

An approximately 3.4 m and 4.1 m thick layer of fill was encountered underlying the concrete in Boreholes TP-03 and TP-04, respectively. The base of the fill layer extends to approximately Elevations 153.6 m and 153.4 m in Boreholes TP-03 and TP-04, respectively. The fill encountered is variable in composition and is generally comprised of clayey silt to sandy clayey silt. A 0.8 m thick layer of sand fill was encountered within the cohesive fill in Borehole TP-04 at a depth of about 1.4 m, corresponding to Elevation 156.4 m. Cobbles / obstructions are inferred to be present within the fill layer due to auger grinding at depths between about 0.6 m and 0.9 m in Borehole TP-03 and below a depth of 4.3 m in borehole TP-04. The sandy clayey silt encountered below a depth of 2.2 m in TP-04 resembled a glacial till and may be recompacted native till material. The till deposits in this area are known to contain cobbles and boulders and thus, the presence of cobbles/boulders should be anticipated within the fill layer.

The SPT “N”-values measured within the cohesive portion of the fill range from 15 blows per 0.3 m of penetration to 100 blows for 0.25 m of penetration, suggesting a stiff to hard consistency. One SPT “N”-value measured within the non-cohesive portion of the fill in Boreholes TP-04 was 45 blows per 0.3 m of penetration, indicating a dense level of compactness.

A grain size distribution was carried out on one sample of the sandy clayey silt fill and the results are shown on Figure B6 in Appendix B. Atterberg limits testing was carried out on two samples of clayey silt fill and measured liquid limits of 20 per cent and 22 per cent, plastic limits of 13 per cent and 14 per cent, and corresponding plasticity indices of 7 per cent and 8 per cent. These results, which are plotted on a plasticity chart on Figure B7 in Appendix B, indicate that the fill is comprised of clayey silt of low plasticity. The natural water content measured on select samples of the clayey silt fill are between 9 per cent and 11 per cent.

A grain size distribution test was carried out on one sample of the sand fill and the results are shown on Figure B8 in Appendix B. The natural water content measured on one sample of the sand fill layer is about 5 per cent.

#### **4.2.2.4 Sand and Gravel**

A 1.2 m and 1.0 m thick sand and gravel deposit was encountered underlying the cohesive fill in Boreholes TP-03 and TP-04, respectively. The surface of the sand and gravel deposit was encountered at Elevations 153.6 m and 153.4 m in Boreholes TP-03 and TP-04, respectively.

The SPT “N”-values measured within the sand and gravel deposit are 54 blows per 0.3 m of penetration to 100 blows for 0.25 m of penetration, indicating a very dense level of compactness.

Grain size distribution tests were carried out on two samples of the sand and gravel and the results are shown on Figure B9 in Appendix B. The natural water content measured on two samples of the sand and gravel deposit is about 5 per cent.

#### **4.2.2.5 Silty Clay (Till)**

A 2.7 m and 1.3 m thick deposit of silty clay till was encountered underlying the sand and gravel deposit in Boreholes TP-03 and TP-04, respectively. The surface of the silty clay glacial till deposit was encountered at Elevation 152.4 m in both boreholes. Although not encountered during drilling operations, cobbles/boulders and shale fragments are known to be present within the glacial till soils in this local region and should be anticipated to be present within this till deposit.

The SPT “N”-values measured within the silty clay till deposit range from 31 to 54 blows per 0.3 m of penetration, suggesting a hard consistency.

A grain size distribution was carried out on one sample of the silty clay till deposit and the results are shown on Figure B10 in Appendix B and confirm a well-graded distribution. Atterberg limits testing was carried out on one selected sample of the silty clay till deposit and measured a liquid limit of 36 per cent, plastic limit of 20 per cent, and a plasticity index of 16 per cent. These results, which are plotted on a plasticity chart on Figure B11 in Appendix B, indicate that the till deposit is a silty clay of intermediate plasticity. The natural water content measured on two selected samples of the silty clay till deposit is about 10 and 14 per cent.

#### **4.2.2.6 Shale**

Shale bedrock was encountered underlying the silty clay till deposit at depths of 7.6 m (Elevations 149.7 m) and 6.7 m (Elevation 151.1 m) in Boreholes TP-03 and TP-04, respectively. The shale was confirmed from limited recovery within split-spoon samples. The shale is inferred to be weathered within the upper portion; however, the amount and extent of weathering was not confirmed as bedrock coring was not carried out.

#### 4.2.2.7 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations. The groundwater level recorded in the open boreholes, if present, are indicated on the borehole records in Appendix A and are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
TP-03	157.3	6.3	151.0	September 10, 2018	Open borehole (borehole caved to 7.0 m)
TP-04	157.8	Dry	-	September 11, 2018	Open borehole

The groundwater level observations at this site are not considered to represent long-term stabilized groundwater levels. The groundwater level will be subject to seasonal fluctuations and precipitation events; the water levels should be expected to be higher during the spring season or during and following periods of heavy precipitation.

#### 4.2.3 Site No. 37-822/1&2 (Bridge 29) – Boreholes TP-05 and TP-06

In general, the subsurface conditions at this site consist of asphalt and concrete associated with the Renforth Drive pavement structure, underlain by fill. The fill material is underlain by cohesionless deposits of silt, gravelly silty sand and sand and gravel. Shale bedrock was encountered below the cohesionless deposits in both boreholes. In Borehole TP-06, a deposit of silty clay till was encountered between the cohesionless deposits and the shale bedrock.

##### 4.2.3.1 Asphalt

An approximately 70 mm and 90 mm thick layer of asphalt pavement was encountered at ground surface in Boreholes TP-05 and TP-06, respectively.

##### 4.2.3.2 Concrete

An approximately 230 mm and 160 mm thick layer of concrete was encountered underlying the asphalt pavement in Boreholes TP-05 and TP-06, respectively.

##### 4.2.3.3 Fill

A 1.2 m and 1.1 m thick layer of fill material was encountered underlying the concrete in Boreholes TP-05 and TP-06, respectively. The fill material was comprised of silty sand in Borehole TP-05 and clayey silt in Borehole TP-06. The base of the fill layer extends to Elevations 160.2 m and 159.9 m in Boreholes TP-05 and TP-06, respectively. Clay pockets were encountered within the silty sand fill in Borehole TP-05 between depths of 0.8 m and 1.4 m.

The Standard Penetration Test (SPT) “N”-value measured within the silty sand fill layer is 17 blows per 0.3 m of penetration, indicating a compact level of compactness. The SPT “N”-value measured within the clayey silt fill layer is 9 blows per 0.3 m of penetration, suggesting a stiff consistency.

#### 4.2.3.4 Silt

A 3.2 m thick deposit of silt was encountered underlying the silty sand fill layer in Borehole TP-05 at a depth of 1.5 m, corresponding to Elevation 160.2 m.

The SPT “N”-values measured within the silt deposit range from 31 blows to 69 blows per 0.3 m of penetration, indicating a dense to very dense level of compactness.

A grain size distribution was carried out on two samples of the silt deposit and the results are shown on Figure B12 in Appendix B. The natural water content measured on three selected samples of the silt deposit range between about 11 and 25 per cent.

#### 4.2.3.5 Gravelly Silty Sand to Sand and Gravel

A 4.0 m thick deposit of gravelly silty sand to sand and gravel was encountered underlying the silt deposit in Borehole TP-05. The deposit grades from a gravelly silty sand to a sand and gravel with depth, with the surface of the gravelly silty sand deposit encountered at Elevation 157.0 m, and the surface of the sand and gravel deposit encountered at Elevation 154.5 m. Cobbles / boulders are inferred to be present within the gravelly silty sand to sand and gravel deposit due to auger grinding at depths below about 5 m, with auger refusal encountered at a depth of about 6.0 m. As a result, Borehole TP-05 was backfilled and relocated about 3 m to the south and re-drilled to 6 m where sampling operations were continued until termination of the borehole.

The SPT “N”-values measured within the gravelly silty sand to sand and gravel deposit range from 61 blows to 86 blows per 0.3 m of penetration, indicating a dense to very dense level of compactness.

A grain size distribution was carried out on one sample of the gravelly silty sand deposit and the results are shown on Figure B13 in Appendix B. The natural water content measured on two selected samples of the gravelly silty sand to a sand and gravel deposit is about 6 and 7 per cent.

#### 4.2.3.6 Sand

A 5.7 m thick sand deposit was encountered underlying the clayey silt fill in Borehole TP-06 at a depth of 1.5 m, corresponding to Elevation 159.9 m. A 0.3 m thick gravelly clayey silt layer was encountered at a depth of 4.2 m within the sand deposit. Cobbles / boulders are inferred to be present within the sand deposit due to effective split-spoon refusal at various sampling intervals below about 2.5 m below ground surface auger grinding during drilling operations at a depth of about 7.0 m.

The SPT “N”-values measured within the sand deposit range from 45 blows per 0.3 m of penetration to 165 blows per 0.28 m of penetration, indicating a dense to very dense level of compactness.

A grain size distribution was carried out on two samples of the sand deposit and the results are shown on Figure B14 in Appendix B. Atterberg limits testing was carried out on one selected sample of the sand deposit and was non-plastic. The natural water content measured on four selected samples of the sand deposit range between about 3 and 10 per cent. The natural water content measured on one selected sample of the gravelly clayey silt layer is about 9 per cent.

#### 4.2.3.7 Silty Clay (Till)

A 1.5 m thick silty clay till deposit was encountered underlying the sand deposit in Borehole TP-06 at a depth of 7.2 m, corresponding to Elevation 154.2 m. Shale fragments were encountered within the silty clay deposit.



Although not encountered during drilling operations, cobbles/boulders are known to be present within the glacial till soils in this local region and should be anticipated to be present within this till deposit.

The SPT “N”-value measured within the silty clay till deposit is 50 blows per 0.3 m of penetration, suggesting a hard consistency.

A grain size distribution was carried out on one sample of the silty clay till deposit and the results are shown on Figure B15 in Appendix B. Atterberg limits testing was carried out on one selected sample of the silty clay till deposit and measured a liquid limit of 36 per cent, plastic limit of 22 per cent, and a plasticity index of 14 per cent. These results, which are plotted on a plasticity chart on Figure B16 in Appendix B, indicate that the deposit is a silty clay of intermediate plasticity. The natural water content measured on one selected sample of the silty clay till deposit is about 11 per cent.

#### 4.2.3.8 Shale

Shale bedrock was encountered underlying the sand and gravel deposit in Borehole TP-05 at a depth of 8.7 m (Elevation 153.0 m) and underlying the silty clay till deposit in Borehole TP-06 at a depth of 8.7 m (Elevation 152.7 m). The shale was confirmed from limited recovery within split-spoon samples. The shale is inferred to be weathered within the upper portion; however, the amount and extent of weathering was not confirmed as bedrock coring was not carried out.

#### 4.2.3.9 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations. The groundwater level recorded is provided on the borehole records in Appendix A and is summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
TP-05	161.7	7.9	153.8	December 16, 2018	Open borehole (borehole caved to 8.2m)
TP-06	161.4	4.6	156.8	December 2, 2018	Open borehole (borehole caved to 5.8m)

The groundwater level observations at this site are not considered to represent long-term stabilized groundwater levels. Groundwater levels will be subject to seasonal fluctuations and precipitation events; the water levels should be expected to be higher during the spring season or during and following periods of heavy precipitation.



## 5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Carter Comish, E.I.T. and reviewed by Ms. Nikol Kochmanová, P.Eng. Mr. Kevin J. Bentley, P.Eng., an Associate and MTO Foundations Designated Contact of Golder, conducted an independent technical and quality control review of this report.

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# PART B

FOUNDATION DESIGN REPORT  
TEMPORARY PROTECTION SYSTEMS AT BRIDGE SITE NOS. 37-819, 37-822  
AND 37-827  
STRUCTURE REHABILITATION AT HIGHWAY 401 / HIGHWAY 427  
CITY OF TORONTO, ONTARIO  
G.W.P. 2032-11-00

## 6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

### 6.1 General

This section of the report provides foundation engineering parameters / values and general design considerations for the proposed temporary protection systems required for rehabilitation of the existing structures listed below.

- Site No. 37-819 (Bridge 25): Eglinton Avenue East - Highway 401 West Collector Ramp over Highway 401
- Site No. 37-822/1&2 (Bridge 29): Renforth Drive N/S over Highway 401
- Site No. 37-827 (Bridge 70): Eglinton Avenue East - Highway 427 North Ramp over Highway 401

This discussion is based on our interpretation of the factual data obtained from the boreholes advanced during the current subsurface investigation. The discussion and geotechnical parameters presented are intended to provide the designers with sufficient information to assess the feasible alternatives of the type of temporary protection systems required.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The proposed bridge rehabilitations include predominantly repairs / replacement of the deck and approach slabs, reconstruction of the top portion of the wingwalls/retaining walls and ballast walls, replacement of expansion joints and abutment bearings, and patch repair of the concrete structures. Based on information from AECOM, the anticipated additional loading (i.e. dead load) on the foundations due to replacement of deck, approach slabs and barrier walls will be less than 10%. Temporary protection systems are required to facilitate the proposed rehabilitation works, while maintaining traffic on the three bridge structures. The depth of excavation is anticipated to extend to approximately the top of abutment stem wall, or up to 3 m below the existing road grade at all three structures. Although the geometry and design of the temporary protection system is the responsibility of the contractor, based on the design drawings provided by AECOM, it is anticipated that the temporary protection systems will be oriented parallel to the roadway along the centerline/median between the travelled lanes within the approach embankment near the bridge abutment of each structure.

### 6.2 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the *Canadian Highway Bridge Design Code* CAN/CSA S6-14 (CHBDC (2014)) and its *Commentary*, the bridge structure and its foundation system may be classified as having large traffic volumes and their performance as having potential impacts on other transportation corridors, resulting in a “typical consequence level” associated with exceeding limit states design.

Based on the level of foundation investigations completed to date at this location in comparison to the degree of site understanding in Section 6.5 of CHBDC (2014), the level of confidence for design of the temporary protection systems for the three structures has been assessed as “typical degree of site and prediction model understanding” based on advancing boreholes at / near each protection system foundation element and through the approach embankments.

The corresponding consequence factor,  $\Psi$ , and geotechnical resistance factors,  $\phi_{gu}$  and  $\phi_{gs}$ , from Tables 6.1 and 6.2 of the CHBDC (2014) should be used for the detail design.

### 6.3 Frost Penetration

As per Ontario Provincial Standard Drawing (OPSD) 3090.101 (Foundation Frost Penetration Depths for Southern Ontario), the frost penetration depth in the area is interpreted to be 1.2 m.

### 6.4 Lateral Earth Pressures for Reconstructed Abutment Walls

The lateral earth pressures acting on the reconstructed abutment walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Depending on the Seismic Performance Category for the structure, seismic (earthquake) loading may also have to be taken into account in the design.

The following recommendations are made concerning the design of the reconstructed abutment walls:

- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 (*Aggregates*) Granular 'A' or Granular B Type II, should be used as backfill behind the walls. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (*Compacting*).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with CHBDC (2014) Section 6.12.3 and Figure 6.6. Hand-operated compaction equipment should be used to compact the backfill soils immediately behind the walls as per OPSS.PROV 501. Other surcharge loadings should be accounted for in the design, as required.
- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.2 m behind the back of the wall on Figure C6.20(a) of the Commentary to the CHBDC (2014). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line flatter than 1 horizontal to 1 vertical (1H:1V) extending up and back from the rear face of the footing or pile cap on Figure C6.20(b) of the Commentary to the CHBDC (2014).

#### 6.4.1 Static Lateral Earth Pressures for Design

The following guidelines and recommendations are provided regarding the assessment of lateral earth pressures for static loading conditions. These lateral earth pressures assume that the ground above the wall will be flat. Where there is sloping ground behind the wall, the coefficient of lateral earth pressure will need to be adjusted to account for the slope as per the Commentary to the CHBDC (2014) Section C6.12.1.

- For a restrained wall, the pressures are based on the fill behind the granular backfill zone, and the following parameters (unfactored) may be used assuming the use of earth fill:

Material	Earth Fill
Soil Unit Weight:	20 kN/m <sup>3</sup>
Coefficients of static lateral earth pressure:	
Active, $K_a$	0.33
At rest, $K_o$	0.50

- For an unrestrained wall, the pressures are based on the engineered granular fill within the backfill zone, and the following parameters (unfactored) may be used:

Material	Granular 'A'	Granular 'B' Type II
Soil Unit Weight:	22 kN/m <sup>3</sup>	21 kN/m <sup>3</sup>
Coefficients of static lateral earth pressure:		
Active, $K_a$	0.27	0.27
At rest, $K_o$	0.43	0.43

- If the wall does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at-rest earth pressures (plus any compaction surcharge) should be assumed for geotechnical design.
- If the wall support and superstructure allow lateral yielding (i.e., unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.6 of the Commentary to the CHBDC (2014).

## 6.5 Temporary Excavation and Groundwater Control

It is understood that the temporary excavations for the bridge rehabilitation works will extend to the top of the abutment stem walls (just below bearings), and up to 3 m below the existing roadway grade at the three structures. The proposed excavations will require removal of the asphalt, concrete (including approach slabs) and existing non-cohesive and cohesive fill material, and may extend into the native sandy silt to sand and sandy silty clay deposits at Site No. 37-827 (Borehole TP-02) and into the native silt and sand deposits at Site No. 37-822/1&2 (Boreholes TP-05 and TP-06). All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects (OHSA). The fills are classified as Type 3 soils above the groundwater level. The native soils are classified as Type 2 soils above the groundwater level, and Type 3 soils if encountered below the groundwater table. Assuming temporary excavations will be less than 3 m deep, groundwater is not expected to be encountered; however, some perched groundwater may be present within non-cohesive fill layers above cohesive fills. Temporary excavations (i.e., those which are open for a relatively short time period) should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V) through the Type 2 and 3 soils. If native soil (Type 2 soil) is encountered near the bottom of the excavations, a vertical cut up to 1.2 m deep can be made below the 1H:1V side slopes.

All excavations must comply with OPSS.PROV 902 (*Excavating and Backfilling – Structures*) requirements, and excavations should be inspected regularly for evidence of instability if they have been left open for an extended period of time. During construction, stockpiles/equipment/materials should be located a minimum distance of 1.5 m from the top of the excavation or a distance equal to the depth of the excavation, whichever is greater; stockpile heights should be controlled to prevent surcharging the sides of the excavation and/or overall slope.

Boreholes TP-01 and TP-04 were dry upon completion of drilling. The water level measured in Borehole TP-02 and TP-03 upon completion of drilling was at a depth of approximately 6.7 m and 6.3 m below ground surface, corresponding to Elevations 151.3 m and 151.0 m, respectively. The water level measured in Borehole TP-05 and TP-06 upon completion of drilling was at a depth of approximately 7.9 m and 4.6 m below ground surface, corresponding to Elevations 153.8 m and 156.8 m, respectively.

The observed water level is below the proposed base of temporary excavation; however, it should be noted that these water levels are not stabilized and groundwater levels may be higher. Groundwater seepage from the non-cohesive fill layers and the non-cohesive native deposits should be expected and can likely be managed using a filtered sump pump system as per OPSS.PROV 517 (*Dewatering*).

Surface water runoff should be controlled and directed away from the excavations during the construction.

## 6.6 Temporary Protection Systems

The temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*). The lateral movement of the protection systems shall meet Performance Level 2 as specified in OPSS.PROV 539.

For conceptual design purposes of temporary excavations less than 3 m deep, it is anticipated that the following systems are considered feasible at Site Nos. 37-819, 37-827 and 37-822/1&2:

- Interlocking sheet pile system;
- Soldier pile and timber lagging system;
- Slide Rail system.

A driven or vibratory interlocking sheet pile system would be feasible at Site Nos. 37-819 and 37-827, and marginally feasible at Site No. 37-822/1&2 provided that the sheet piles can be advanced sufficient depth through the hard zones of the sandy clayey silt fill, the dense to very dense native silt, sand to sand and gravel deposits, and if necessary, into the hard silty clay till soils to provide adequate passive resistance. Difficulties advancing sheet piles through potential cobbles / obstructions encountered in the fill at depths of 1.5 m in TP-02, 0.6 m to 0.9 m in TP-03, and below 4 m depth in TP-04 should be anticipated. Difficulties advancing sheet piles below 2.5 m below ground surface through the “100-blow” soils in the native sand and below about 6 m through cobbles / boulders inferred from auger refusal in the gravelly sand to sand and gravel at Site No. 37-822/1&2 should be expected. Increased thickness of sheet pile section, predrilling, and/or removal of such obstructions may be required. Consideration could be given to excavating a narrow trench and removing any obstructions within the proposed footprint and backfilling with a granular material prior to installing the sheetpiles. Interlocking sheet piles will aid in controlling any water seepage if perched groundwater is encountered during excavation.

Soldier pile and timber lagging systems may also be considered at Site Nos. 37-819, 37-827, and 37-822/1&2. The protection system would consist of conventional steel H-piles (soldier piles) driven into and/or drilled and concrete socketed a sufficient depth into the fill soils, native dense to very dense silt, sandy silt to sand, sand and gravel and silty clay till to provide the necessary passive resistance. Difficulties driving the piles through the potential obstructions/cobbles within the fill soil and very dense / hard “100-blow” soils (i.e. silt to silty sand to sand to sand and gravels, and silty clay till) should be anticipated which could cause piles to “hang up” or be deflected away from vertical. Consideration should be given to predrilling and socketing the steel piles into concrete filled holes, thus temporary liners may be required to keep the holes open during installation and concrete placement. Timber lagging should be installed as the excavation for the cut progresses such that the unsupported height does not exceed 1.2 m at any time, and the space behind the lagging should be immediately packed with granular material to ensure intimate contact of the soil with the back of the wall.

Slide rail systems may also be considered; however, advancement of the driven post supports and steel panels prior to excavation would be necessary to maintain intimate contact with the adjacent soil. This type of system is

considered marginally feasible due to difficulties anticipated advancing the corner posts and panel sections due to the potential for the posts / panels to “hang up” or meet refusal on the obstructions / cobbles encountered within the fill soils and underlying very dense silts, sands, gravels, and silty clay till soils (potentially containing cobbles/boulders). The system could be combined with struts / walers to limit the required depth of penetration, as it is likely that penetration of the panels through the very dense sand and gravels and hard silty clay till containing cobbles/boulders will be challenging and may not be practical, especially at Site No. 37-822/1&2. If excavation occurs prior advancing the panels (i.e. if traditional “dig and push” methods are used), there is a risk of lateral ground movements and subsidence of the adjacent roadway and the design Performance Level may be compromised.

The sheet piles and/or soldier piles will need to extend/be socketed to a sufficient depth through the fills and into the native silt, sandy silt to sand, sand and gravel, and sandy clayey silt to silty clay till to provide the necessary passive resistance for the retained soil height, plus any surcharge loads behind the protection system. Lateral support to the sheet pile wall or soldier pile and lagging wall could be provided in the form of rakers, struts or corner / cross-bracing as required.

While the selection and design of the protection system will be the responsibility of the contractor, the following information is provided to MTO and its designers to aid in assessment and feasibility of temporary protection systems.

Site Location	Soil Type	Unit Weight ( $\gamma$ , kN/m <sup>3</sup> )	Internal Angle of Friction ( $\Phi$ , degrees)	Coefficient of Lateral Earth Pressure <sup>1</sup>		
				Active $K_a$	At Rest $K_o$	Passive $K_p$ <sup>2</sup>
Site No. 37-827	Sandy Clayey Silt Fill (Stiff to Hard)	19	30	0.33	0.50	3.00
	Sandy Clayey Silt (Stiff to Hard)	20	30	0.33	0.50	3.00
	Sandy Silt to Sand / Sand and Gravel (Dense to Very Dense)	20	34	0.28	0.44	3.54
	Silty Clay Till (Hard)	20	32	0.31	0.47	3.25
Site No. 37-819	Clayey Silt Fill (Stiff to Hard)	19	30	0.33	0.50	3.00
	Sand and Gravel (Compact to Very Dense)	21	35	0.27	0.43	3.69
	Silty Clay (Hard)	20	32	0.31	0.47	3.25
Site No. 37-822/1&2	Silty Sand Fill (Compact)	19	30	0.33	0.50	3.00
	Clayey Silt Fill (Stiff)	19	30	0.33	0.50	3.00

Site Location	Soil Type	Unit Weight ( $\gamma$ , kN/m <sup>3</sup> )	Internal Angle of Friction ( $\Phi$ , degrees)	Coefficient of Lateral Earth Pressure <sup>1</sup>		
				Active $K_a$	At Rest $K_o$	Passive $K_p$ <sup>2</sup>
	Silt (Dense to Very Dense)	20	33	0.29	0.46	3.39
	Gravelly Silty Sand to Sand and Gravel (Very Dense)	21	35	0.27	0.43	3.69
	Sand (Dense to Very Dense)	20	34	0.28	0.44	3.54
	Silty Clay Till (Hard)	20	32	0.31	0.47	3.25

1. The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present behind the temporary protection system, the coefficient of earth pressure should be adjusted accordingly.
2. The total passive resistance below the base of the excavation (i.e., adjacent to the protection system) may be calculated based on the values of  $K_p$  indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.16 of the CHBDC (2014) to account for the fact that a large strain would be required for mobilization of the full passive resistance. Appropriate limit state resistance factors should also be used for design.

It should be noted that the pressure distributions resulting from the above parameter values are unfactored for the ultimate stress condition. Appropriate factors for ultimate limit states design according to CHBDC (2014) must be applied and serviceability limits states must also be checked to maintain displacements within the acceptable range according to structural limits and tolerance criteria for Performance Level 2 (OPSS.PROV 539).

Depending on the time of year, perched water may be encountered in the non-cohesive fill materials, above the cohesive fill and native deposits. As noted above, if perched groundwater is present and/or where the installation of soldier piles or excavation extends below the groundwater level at the site, it will be necessary to control seepage for concrete placement and/or include measures to mitigate loss of soil particles through lagging boards if a soldier pile and lagging system is employed.

The design of the temporary protection systems should include an evaluation of base stability, soil squeezing stability, and hydraulic uplift stability.

Consideration could be given to either partial or full removal of the protection system upon completion of construction or each stage of construction (as required). Where possible, full removal of the protection system should be considered to mitigate potential impediments to future rehabilitation/reconstruction work at the bridge sites, or to the road structure above. If the temporary protection system is left in place, it should be removed / cut-off not less than 1.5 m below the underside of the pavement structure. Considering the option to fully or partially remove the protection system will be up to the contractor, the standard language in OPSS.PROV 539 is considered acceptable; however an NSSP is required to outline details of the partial removal option. An example NSSP is included in Appendix C.

## 6.7 Construction Concerns

The fill soils, silt to sandy silt to sand, gravelly silty sand to sand and gravel, silty clay and silty clay till deposits potentially contain obstructions such as shale fragments, cobbles, and/or boulders. The depth at which potential



obstructions, as inferred from auger grinding during field investigation and/or auger refusal, are anticipated to be encountered as described in the Foundation Investigation Report (Part A of this report) and associated Record of Boreholes. It is recommended that a Notice to Contractor be included in the Contract Documents to alert the Contractor of the presence of obstructions such as cobbles and/or boulders within the overburden soils; an example is provided in Appendix C.

## 6.8 Embankment Restoration and Erosion Protection

As part of the rehabilitation works, portions of the existing embankment side-slopes may be disturbed and will require restoration using engineered fill. In landscape areas, suitable earth fill material may be used to restore slopes. In settlement sensitive areas, the embankment material should be restored using Granular 'B' Type I or Select Subgrade Material meeting the specifications of OPSS.PROV 1010 (*Aggregates*). The embankment fill should be placed and compacted in horizontal layers after the slope face has been leveled in general accordance with OPSS 208.010 (*Benching of Earth Slopes*), OPSS.PROV 501 (*Compacting*) and OPSS.PROV 206 (*Grading*). The final embankment side slopes should be constructed to an inclination no steeper than 2H:1V.

All engineered fill should be placed in lifts as per OPSS.PROV 206 (*Grading*) and compacted to at least 95 per cent of the Standard Proctor Maximum Dry Density of the material. Inspection and field density testing should be carried out by qualified personnel during engineered fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

To reduce surface water erosion on the embankment side slopes, topsoil and seeding as per OPSS 802 (*Topsoil*) and OPSS.PROV 804 (*Seed and Cover*) should be carried out as soon as possible after construction / restoration of the embankments. If this slope protection is not in place before winter, then alternate protection measures, such as covering the slope with straw or gravel sheeting, as per OPSS 511 (*Rip Rap, Rock Protection and Granular Sheeting*) and OPSS.PROV 1004 (*Aggregates – Miscellaneous*), should be carried out to reduce the potential for erosion and the requirement of remedial works on the side slopes in the spring prior to topsoil dressing and seeding.

## 7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Carter Comish, E.I.T. and reviewed by Ms. Nikol Kochmanová, P.Eng. Mr. Kevin J. Bentley, P.Eng., an Associate and MTO Foundations Designated Contact of Golder, conducted an independent technical and quality control review of this report.

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- Chapman, L.J. and Putnam, D. F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.
- Unified Facilities Criteria, U.S. Navy. 1986. NAVFAC Design Manual 7.02. Soil Mechanics, Foundation and Earth Structures. Alexandria, Virginia.

### ASTM International

ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

### Ontario Provisional Standard Drawing (OPSD):

OPSD 3090.101 Foundation Frost Penetration Depths for Southern Ontario

### Ontario Provincial Standard Specifications (OPSS):

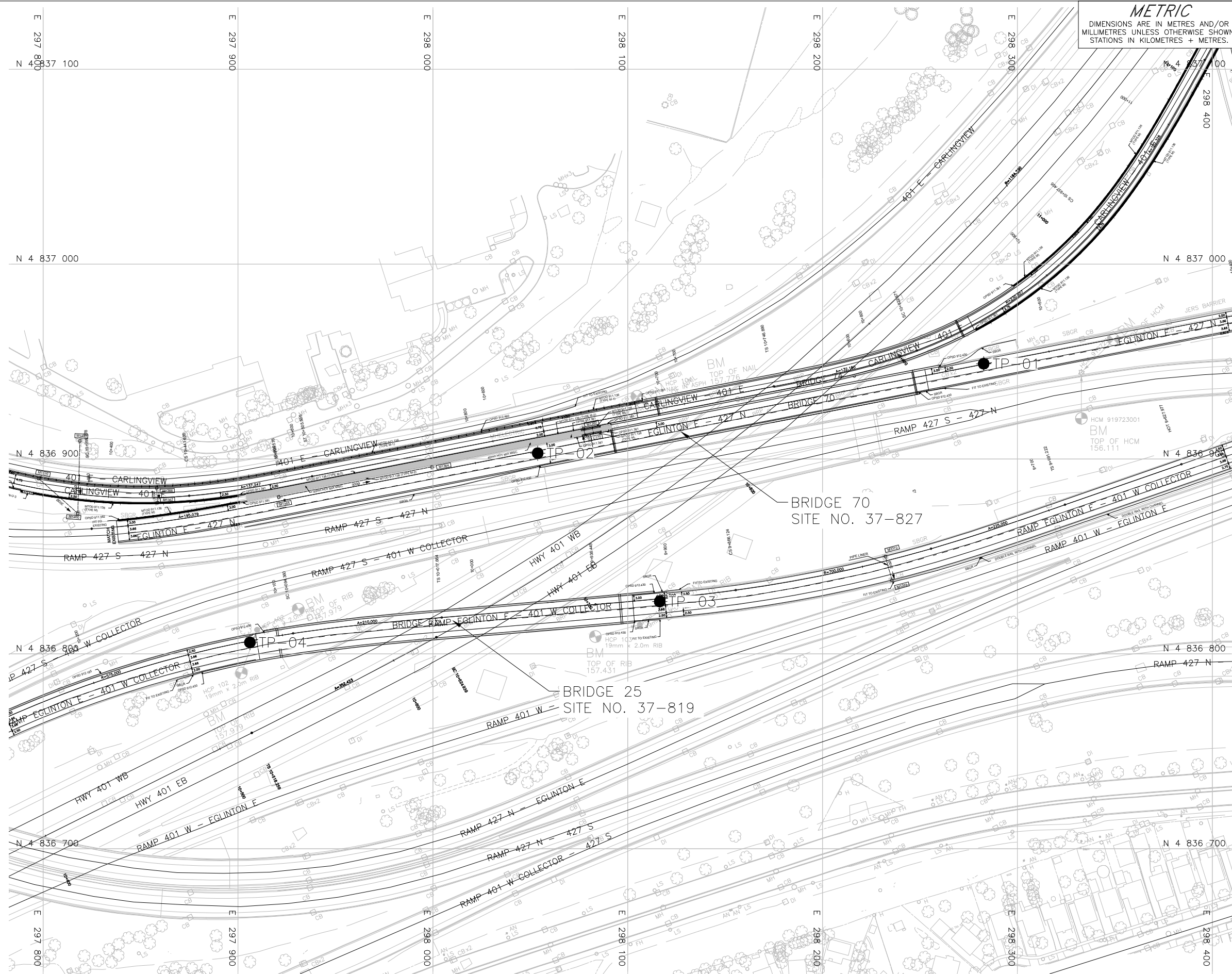
OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 501	Construction Specifications for Compacting
OPSS 511	Construction Specification for Rip Rap, Rock Protection and Granular Sheetting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
OPSS.PROV 1014	Construction Specification for Aggregates - Miscellaneous

### Ontario Water Resources Act

Ontario Regulation 903/90 Wells: O. Reg. 468/10 Amendment to Ontario Regulation 903

### Ontario Occupational Health and Safety Act

Ontario Regulation 213 (Construction Projects)



PLAN  
SCALE  
20 0 20 40 m

**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 2032-11-00



HIGHWAY 401/427 INTERCHANGE  
TEMPORARY PROTECTION SYSTEMS - SITE NO.  
37-827 AND 37-819  
BOREHOLE LOCATIONS

SHEET



KEY PLAN

SCALE  
2 0 2 4 km

LEGEND

● Borehole - Current Investigation

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
TP-01	155.5	4836948.9	298282.7
TP-02	158.0	4836903.0	298053.8
TP-03	157.3	4836826.9	298116.4
TP-04	157.8	4836805.9	297906.1



NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

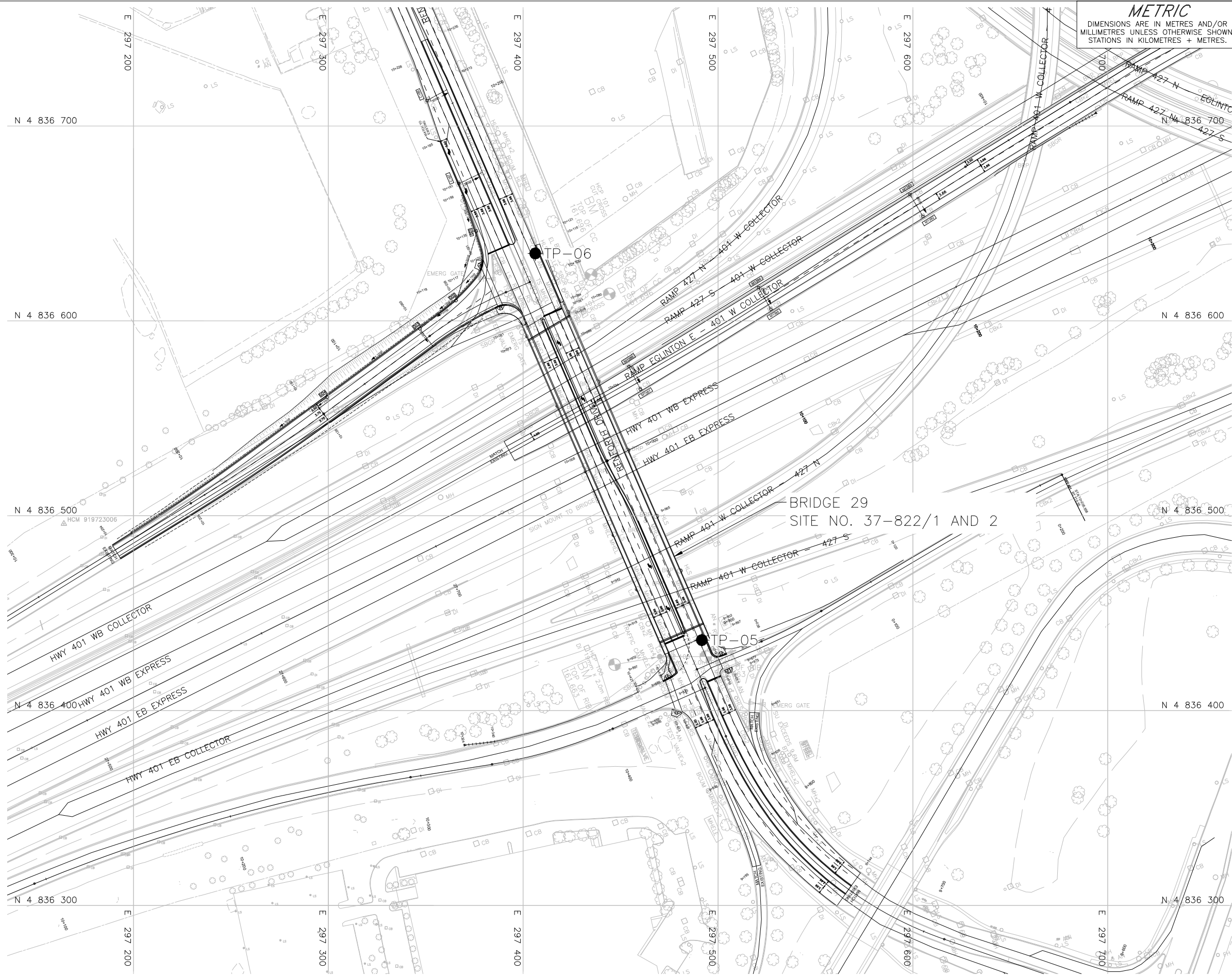
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by AECOM, drawing file nos. Hwy401\_base\_C1.dwg, Hwy401\_KM\_alignment\_C1.dwg and 401KM\_NC\_C1.dwg, received November 05, 2018.

NO.	DATE	BY	REVISION
Geocres No. 30M11-285			
HWY. 401		PROJECT NO. 1665765	DIST. .
SUBM'D. CC	CHKD. CC	DATE: 02/11/2019	SITE: .
DRAWN: DD	CHKD. NK	APPD. KJB	DWG. 1



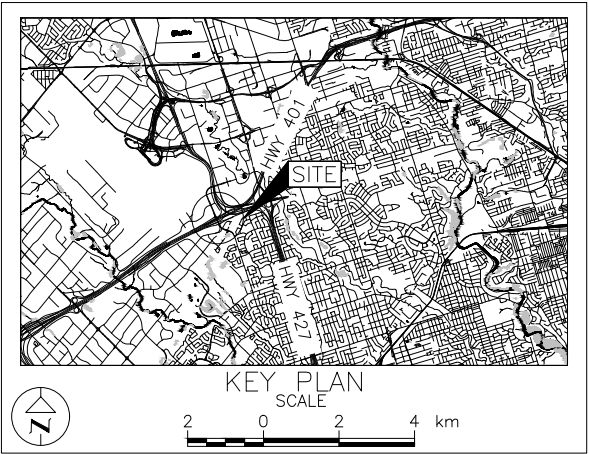


**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 2032-11-00

HIGHWAY 401/427 INTERCHANGE  
TEMPORARY PROTECTION SYSTEMS - SITE NO.  
37-822/1 AND 2  
BOREHOLE LOCATIONS

SHEET



LEGEND

Borehole - Current Investigation

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)			
No.	ELEVATION	NORTHING	EASTING
TP-05	161.7	4836436.2	297491.7
TP-06	161.4	4836634.6	297406.2



**NOTES**

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

**REFERENCE**

Base plans provided in digital format by AECOM, drawing file nos. Hwy401\_base\_C1.dwg, Hwy401\_KM\_alignment\_C1.dwg and 401KM\_NC\_C1.dwg, received November 05, 2018.

NO.	DATE	BY	REVISION
Geocres No. 30M11-285			
HWY. 401		PROJECT NO. 1665765	DIST. .
SUBM'D. CC	CHKD. CC	DATE: 02/11/2019	SITE: .
DRAWN: DD	CHKD. NK	APPD. KJB	DWG. 2

**APPENDIX A**

# Borehole Records

## LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

### I. GENERAL

$\pi$	3.1416
$\ln x$ ,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

#### (a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation

#### (a) Index Properties (continued)

w	water content
$w_l$ or LL	liquid limit
$w_p$ or PL	plastic limit
$I_p$ or PI	plasticity index = $(w_l - w_p)$
$w_s$	shrinkage limit
$I_L$	liquidity index = $(w - w_p) / I_p$
$I_c$	consistency index = $(w_l - w) / I_p$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$I_D$	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

#### (b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

#### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_{\alpha}$	secondary compression index
$m_v$	coefficient of volume change
$C_v$	coefficient of consolidation (vertical direction)
$C_h$	coefficient of consolidation (horizontal direction)
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	effective cohesion
$c_u, s_u$	undrained shear strength ( $\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
$p'$	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
$q_u$	compressive strength $(\sigma_1 - \sigma_3)$
$S_t$	sensitivity

\* Density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1  
2

$\tau = c' + \sigma' \tan \phi'$   
shear strength = (compressive strength)/2

## LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

### I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

#### Dynamic Cone Penetration Resistance; $N_d$ :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive (Cohesionless) Soils

Compactness	N
Condition	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

#### (b) Cohesive Soils Consistency

	$C_u, S_u$	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

**Note:** 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

### V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



PROJECT		1665765		RECORD OF BOREHOLE No TP-01		SHEET 1 OF 1		METRIC								
G.W.P.		2032-11-00		LOCATION		N 4836948.9; E 298282.7 MTM NAD 83 ZONE 10 (LAT. 43.672466; LONG. -79.580825)		ORIGINATED BY								
DIST		Central HWY 401		BOREHOLE TYPE		178 mm O.D. Hollow Stem Augers, CME 55 Truck Mounted Drill Rig		COMPILED BY								
DATUM		Geodetic		DATE		September 11, 2018		CHECKED BY								
NK																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
155.5	GROUND SURFACE															
0.0	ASPHALT (90 mm)															
0.3	CONCRETE (220 mm)															
	Sandy clayey silt, trace to some gravel, trace organics (rootlets) between 3.7 m and 4.5 m (FILL) Stiff to hard Brown to grey, mottled at 1.5 m Moist		1	SS	29											
			2	SS	24											
			3	SS	61											
			4	SS	13											
			5	SS	12											
151.0																
4.5	Sandy CLAYEY SILT, trace to some gravel Stiff to hard Brown/grey mottling throughout Moist		6	SS	15											
			7	SS	63											
148.3																
7.2	SAND and SILT, some gravel, trace clay Very dense grey Moist - Auger grinding at 7.9 m		8	SS	72/0.13											
147.0																
8.5	SILTY CLAY, trace sand, trace gravel (TILL) Hard Grey Moist		9	SS	100/0.28											
145.9																
9.6	END OF BOREHOLE															
	NOTES: 1. Borehole caved to 8.1 m on removal of augers. 2. Open borehole dry on completion of drilling.															

PROJECT		1665765		RECORD OF BOREHOLE No TP-02				SHEET 1 OF 1		METRIC					
G.W.P.		2032-11-00		LOCATION				N 4836903.0; E 298053.8 MTM NAD 83 ZONE 10 (LAT. 43.672051; LONG. -79.583663)		ORIGINATED BY		AJ			
DIST		Central HWY 401		BOREHOLE TYPE				178 mm O.D. Hollow Stem Augers, CME 55 Truck Mounted Drill Rig		COMPILED BY		EN			
DATUM		Geodetic		DATE				September 12, 2018		CHECKED BY		NK			
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
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PROJECT		1665765		RECORD OF BOREHOLE No TP-03		SHEET 1 OF 1		METRIC							
G.W.P.		2032-11-00		LOCATION		N 4836826.9; E 298116.4 MTM NAD 83 ZONE 10 (LAT. 43.671367; LONG. -79.582886)		ORIGINATED BY							
DIST		Central HWY 401		BOREHOLE TYPE		178 mm O.D. Hollow Stem Augers, CME 55 Truck Mounted Drill Rig		COMPILED BY							
DATUM		Geodetic		DATE		September 10, 2018		CHECKED BY							
NK															
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES									
157.3		GROUND SURFACE													
0.0		ASPHALT (90 mm)													
0.3		CONCRETE (230 mm)													
		Clayey silt, trace to some sand, some gravel (FILL) Stiff to hard Brown to grey, mottled at 2.3 m Moist - Auger grinding between 0.6 m and 0.9 m.		1	SS	32									
				2	SS	15									
				3	SS	24									
				4	SS	33									
153.6		SAND and GRAVEL, trace to some silt, trace clay, higher clay and silt content at a 4.6 m Very dense Brown Moist		5	SS	100/0.25									
				6	SS	54									
152.4		SILTY CLAY, some sand, some gravel (TILL) Hard Grey Moist													
				7	SS	31									
149.7		Weathered SHALE (BEDROCK)		8	SS	100/0.0									
148.1		END OF BOREHOLE		9	SS	100/0.10									
9.2		NOTES: 1. Borehole caved to 7.0 m on removal of augers. 2. Water level in open borehole at a depth of 6.3 m (Elev. 151.0 m) upon completion of drilling.													

PROJECT		1665765		RECORD OF BOREHOLE				No TP-04		SHEET 1 OF 1		METRIC					
G.W.P.		2032-11-00		LOCATION		N 4836805.9; E 297906.1 MTM NAD 83 ZONE 10 (LAT. 43.671176; LONG. -79.585494)				ORIGINATED BY		AJ					
DIST		Central		HWY		401		BOREHOLE TYPE		178 mm O.D. Hollow Stem Augers, CME 55 Truck Mounted Drill Rig				COMPILED BY		EN	
DATUM		Geodetic		DATE		September 11, 2018				CHECKED BY		NK					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × REMOULDED</div></div>									
157.8	GROUND SURFACE																
0.0	ASPHALT (100 mm)																
0.3	CONCRETE (230 mm)																
	Clayey silt, some sand, some gravel (FILL)																
	Hard																
	Brown to grey																
	Moist		1	SS	45		157										
156.4																	
1.4	Sand, some gravel, some silt, trace clay (FILL)																
	Dense																
	Brown																
	Moist		2	SS	45		156								18 65 13 4		
155.6																	
2.2	Sandy clayey silt, trace to some gravel (FILL)																
	Very stiff to hard																
	Grey																
	Moist																
			3	SS	33		155										
			4	SS	27		154								6 34 43 17		
			5	SS	100/0.25		154										
153.4																	
4.4	- Auger grinding between 4.3 m and 5.5 m																
	SAND and GRAVEL, trace to some silt, trace clay																
	Very dense																
	Brown																
	Moist																
			6	SS	100/0.25		153								38 47 11 4		
152.4																	
5.4	SILTY CLAY, some sand (TILL)																
	Hard																
	Grey																
	Moist																
			7	SS	36		152										
151.1																	
6.7	Weathered SHALE (BEDROCK)																

PROJECT		1665765		RECORD OF BOREHOLE No TP-05		SHEET 1 OF 1		METRIC									
G.W.P.		2032-11-00		LOCATION		N 4836436.2; E 297491.7 MTM NAD 83 ZONE 10 (LAT. 43.667844; LONG. -79.590627)		ORIGINATED BY									
DIST		Central HWY 401		BOREHOLE TYPE		152 mm O.D. Hollow Stem Augers, CME 55 Truck Mounted Drill Rig		COMPILED BY									
DATUM		Geodetic		DATE		December 16, 2018		CHECKED BY									
								NK									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
161.7	GROUND SURFACE																
0.0	ASPHALT (70 mm)																
0.3	CONCRETE (230 mm)																
160.2	Silty sand, some gravel (FILL) Compact Brown Moist - Clay pockets from 0.8 m to 1.4 m		1	SS	17												
1.5	SILT, trace sand, trace clay Dense to very dense Brown Moist becoming wet below 3.7 m		2	SS	31												
			3	SS	63												
			4	SS	69												
			5	SS	45												
157.0	Gravelly silty SAND Very dense Brown Moist - Auger grinding at 5.0 m		6A 6B	SS	61												
4.7	- Auger refusal encountered at a depth of 6.0 m; borehole was moved 3.0 m to the south		7	SS	86												
154.5	SAND and GRAVEL, some silt Very dense Brown-grey Moist		8	SS	63												
7.2																	
153.0	SHALE, weathered (BEDROCK) Grey		9	SS	100/0.13												
8.7																	
152.3	END OF BOREHOLE																
9.4	NOTES:  1. Auger refusal was encountered at a depth of 6.0 m and borehole was moved 3.0 m to the south and drilling operations continued.  2. Borehole dry on completion of drilling.  3. Borehole caved to 8.2 m on removal of augers.  4. Water level in open borehole at a depth of 7.9 m below ground surface (Elev. 153.8 m) on removal of augers.																

PROJECT		1665765		RECORD OF BOREHOLE		No TP-06		SHEET 1 OF 1		METRIC								
G.W.P.		2032-11-00		LOCATION		N 4836634.6; E 297406.2 MTM NAD 83 ZONE 10 (LAT. 43.669629; LONG. -79.591690)		ORIGINATED BY		EN								
DIST		Central HWY 401		BOREHOLE TYPE		152 mm O.D. Hollow Stem Augers, CME 55 Truck Mounted Drill Rig		COMPILED BY		EN								
DATUM		Geodetic		DATE		December 2, 2018		CHECKED BY		NK								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
161.4	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT (90 mm)																	
0.3	CONCRETE (160 mm)																	
	Clayey silt, some sand, trace gravel (FILL)																	
	Stiff																	
	Brown																	
	Moist																	
159.9			1	SS	9													
1.5	SAND, some gravel, trace to some silt, trace clay																	
	Dense to very dense																	
	Brown																	
	Moist																	
			2	SS	45													
			3	SS	100/0.23													
			4	SS	122													
			5A	SS	99													
157.2	Gravelly CLAYEY SILT, some sand																	
	Hard																	
	Grey																	
156.9	SAND, some gravel, trace to some silt, trace clay																	
4.5	Very dense																	
	Grey																	
	Wet																	
			6	SS	67													
			7	SS	165/0.28													
154.2	- Auger grinding at 7.0 m depth																	
7.2	SILTY CLAY, some sand, trace gravel, contains trace shale fragments (TILL)																	
	Hard																	
	Grey																	
			8	SS	50													
152.7	SHALE, weathered (BEDROCK)																	
8.7	Grey																	
	Moist																	
152.1	- Auger grinding at 8.8 m																	
9.3	END OF BOREHOLE																	
	NOTES:																	
	1. Water level at a depth of 9.0 m below ground surface (Elev. 152.4 m) inside augers on completion of drilling.																	
	2. Borehole caved to 5.8 m on removal of auger.																	
	3. Water level at a depth of 4.6 m below ground surface (Elev. 156.8 m) after removal of augers.																	

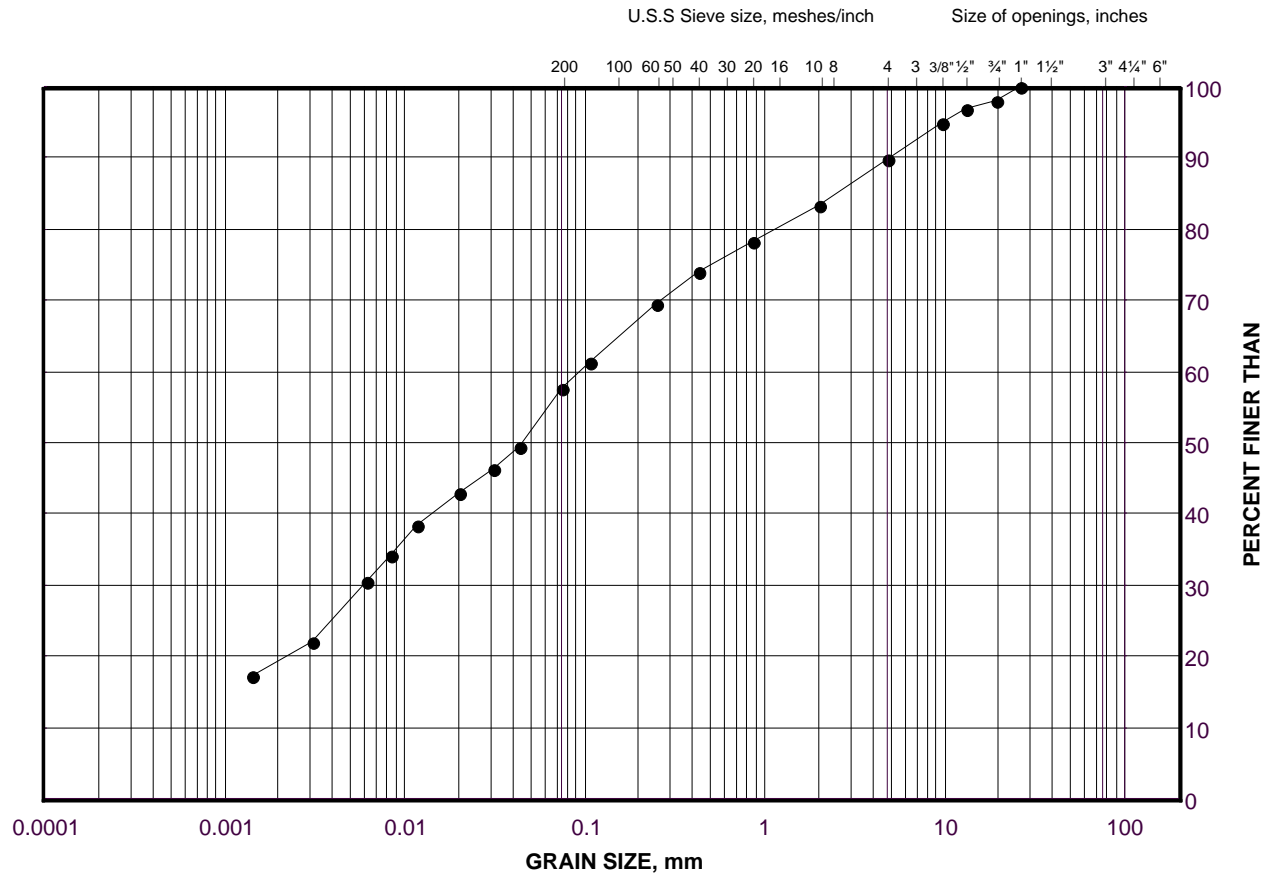
**APPENDIX B**

# Geotechnical Laboratory Test Results

# GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt (Fill)

FIGURE B1



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
•	TP-01	2	153.7

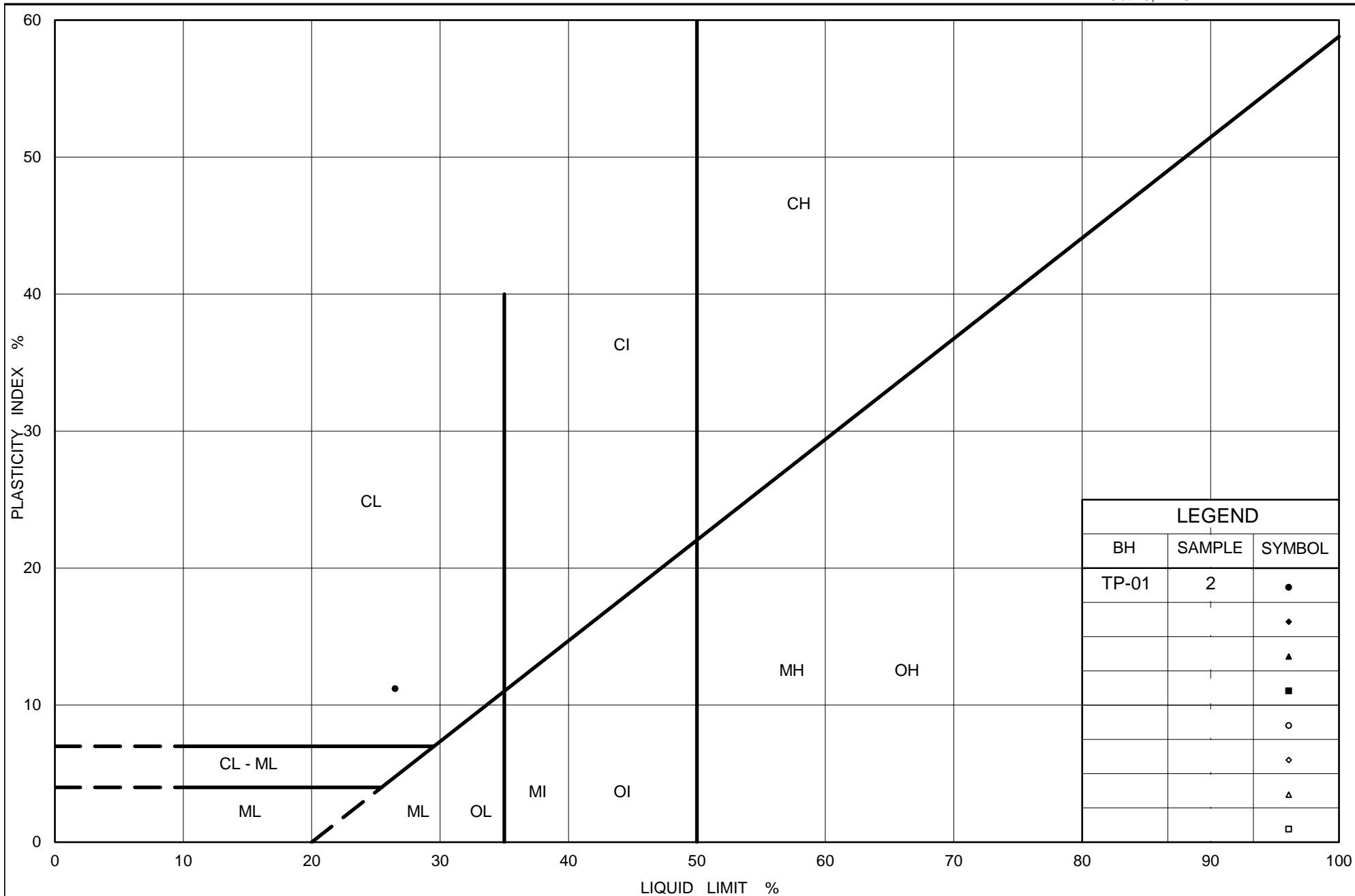
Project Number: 1665765

Checked By: NK

**Golder Associates**

Date: 28-Nov-18





Ministry of Transportation

Ontario

## PLASTICITY CHART

### Sandy Clayey Silt (Fill)

Figure No. B2

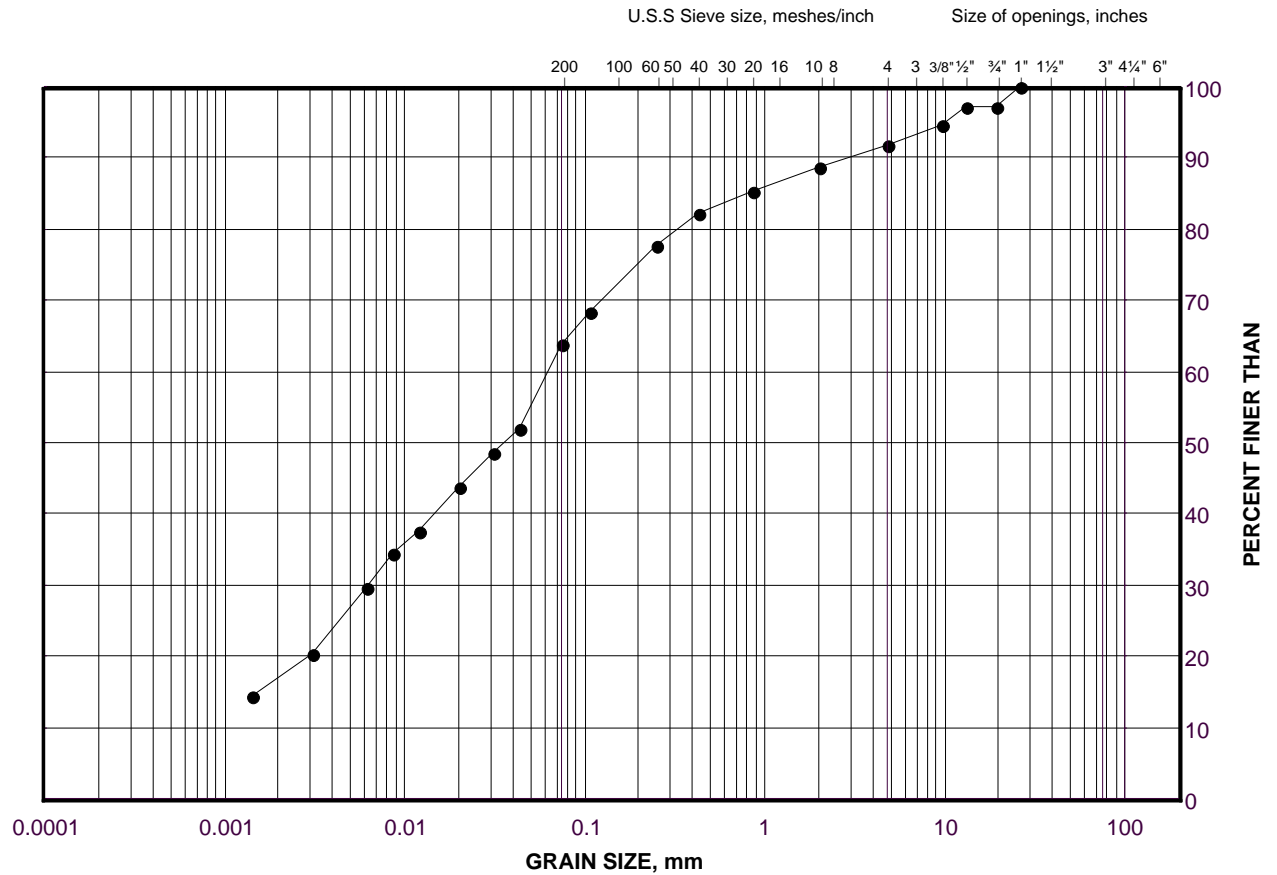
Project No. 1665765

Checked By: NK

# GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt

FIGURE B3



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

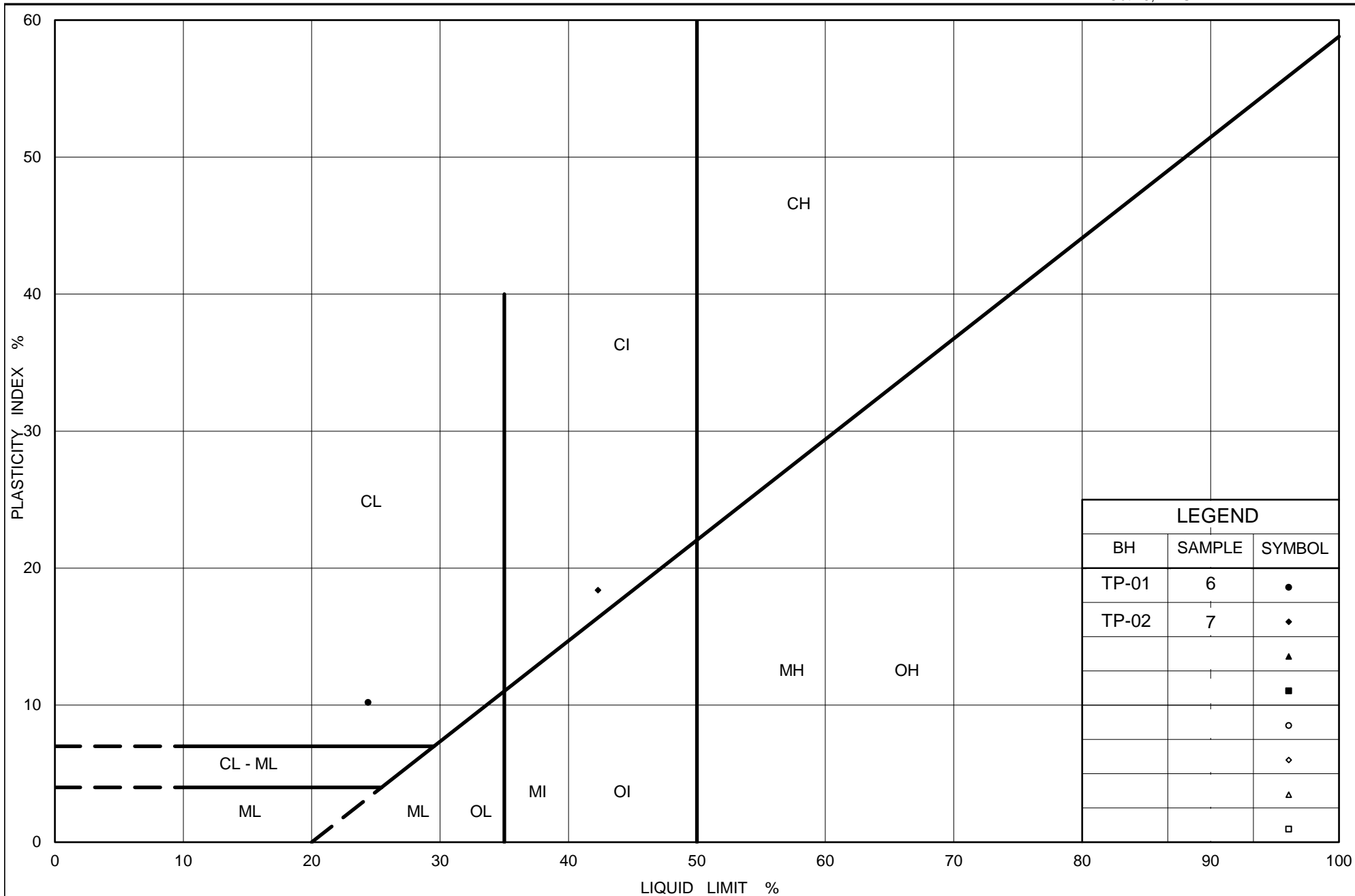
SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
•	TP-01	6	150.6

Project Number: 1665765

Checked By: NK

**Golder Associates**

Date: 28-Nov-18



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# PLASTICITY CHART Silty Clay to Sandy Clayey Silt

Figure No. B4

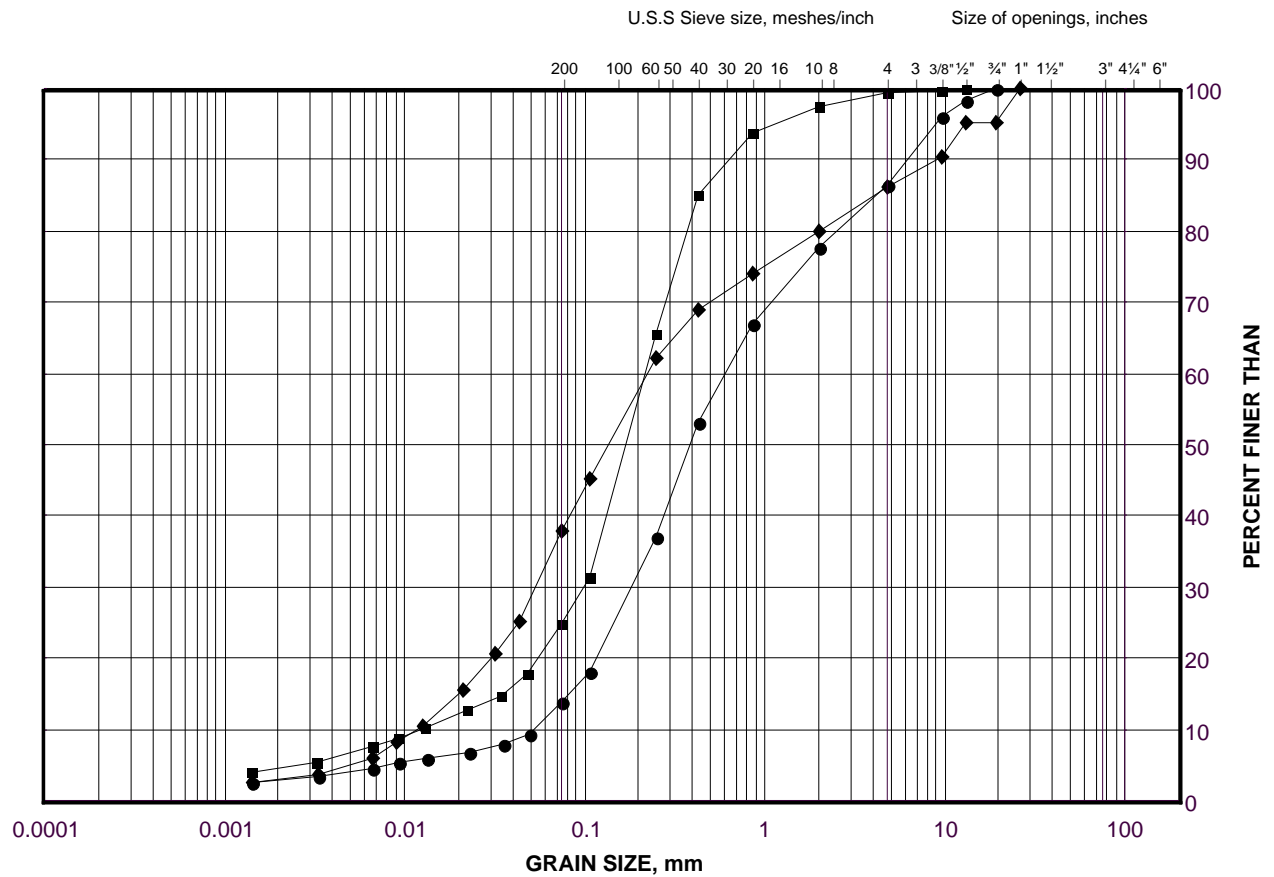
Project No. 1665765

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# GRAIN SIZE DISTRIBUTION

Sandy Silt to Sand

FIGURE B5



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

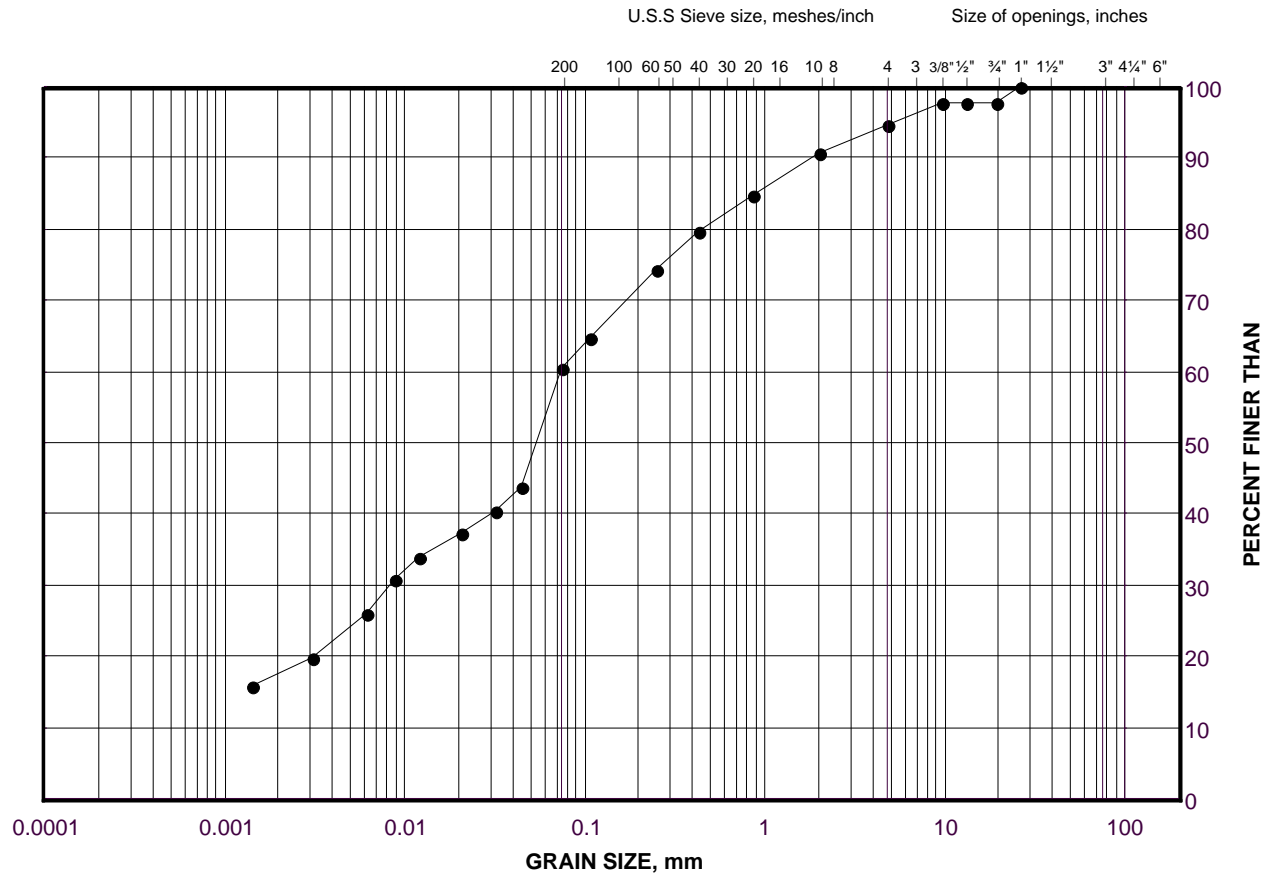
## LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
●	TP-02	3A	155.5
■	TP-02	5	153.9
◆	TP-01	8	147.7

# GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt (Fill)

FIGURE B6



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

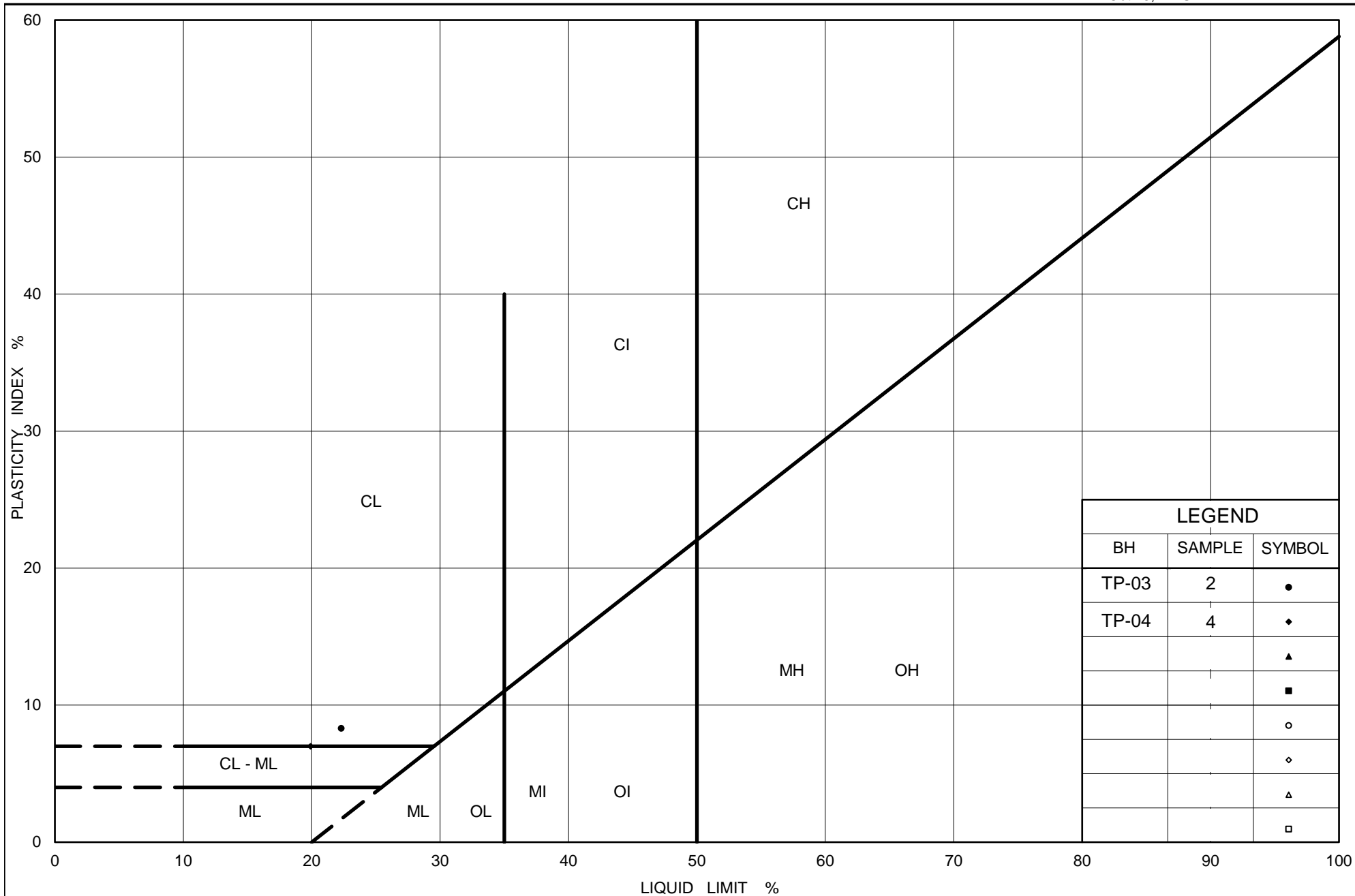
SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
•	TP-04	4	154.5

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Date: 28-Nov-18



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# PLASTICITY CHART Clayey Silt to Sandy Clayey Silt (Fill)

Figure No. B7

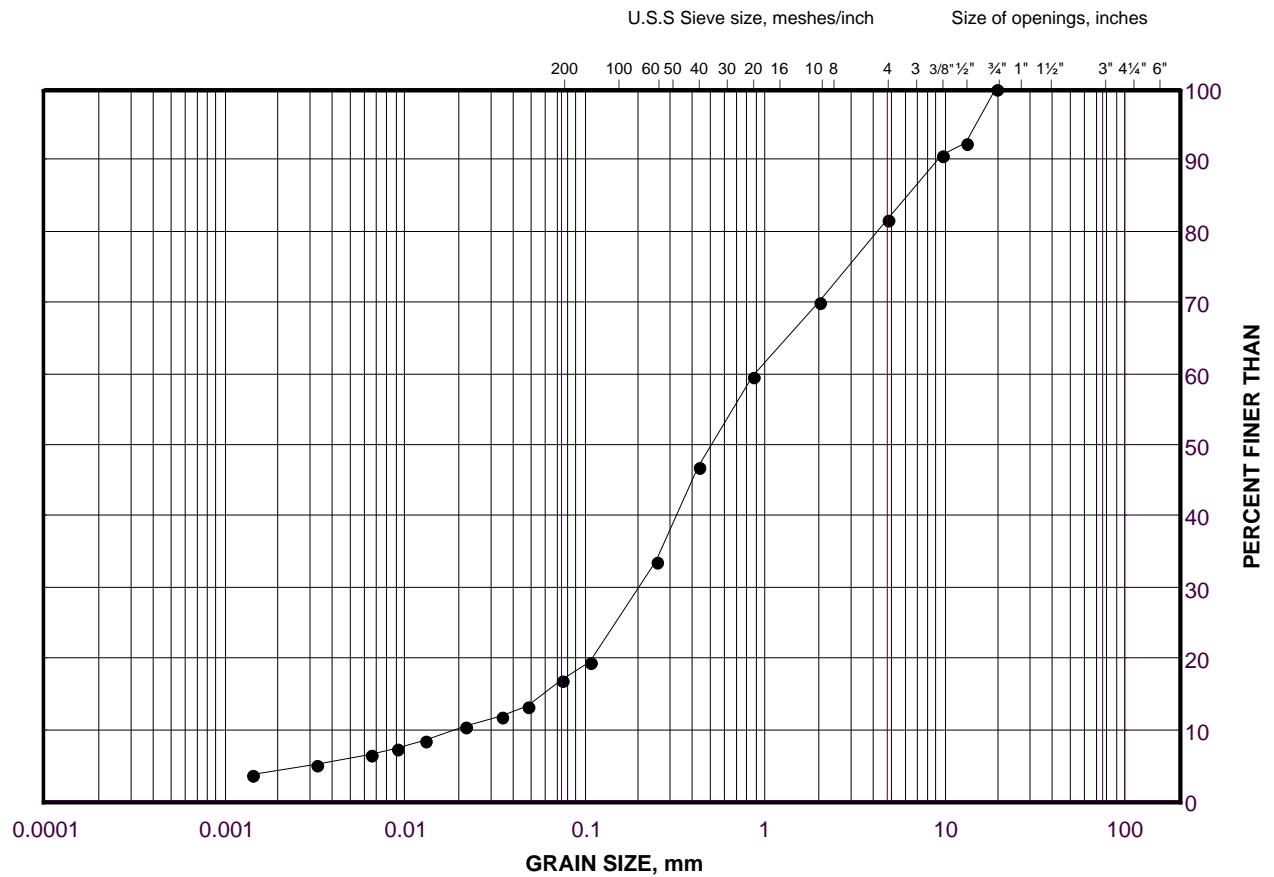
Project No. 1665765

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# GRAIN SIZE DISTRIBUTION

Sand (Fill)

FIGURE B8



SILT AND CLAY SIZES			FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED			SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
•	TP-04	2	156.0

Project Number: 1665765

Checked By: NK

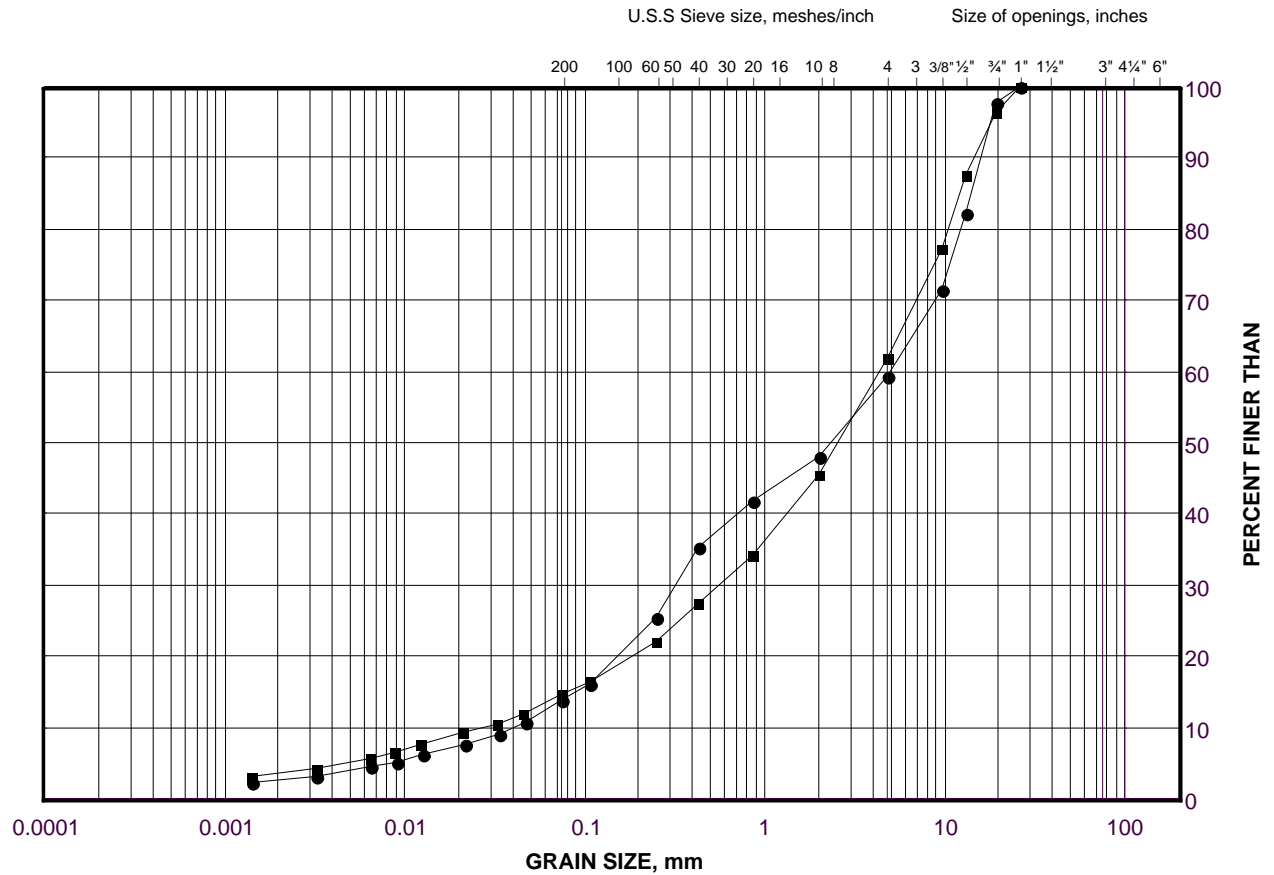
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Date: 28-Nov-18

# GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE B9



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
●	TP-03	5	153.2
■	TP-04	6	153.1

Project Number: 1665765

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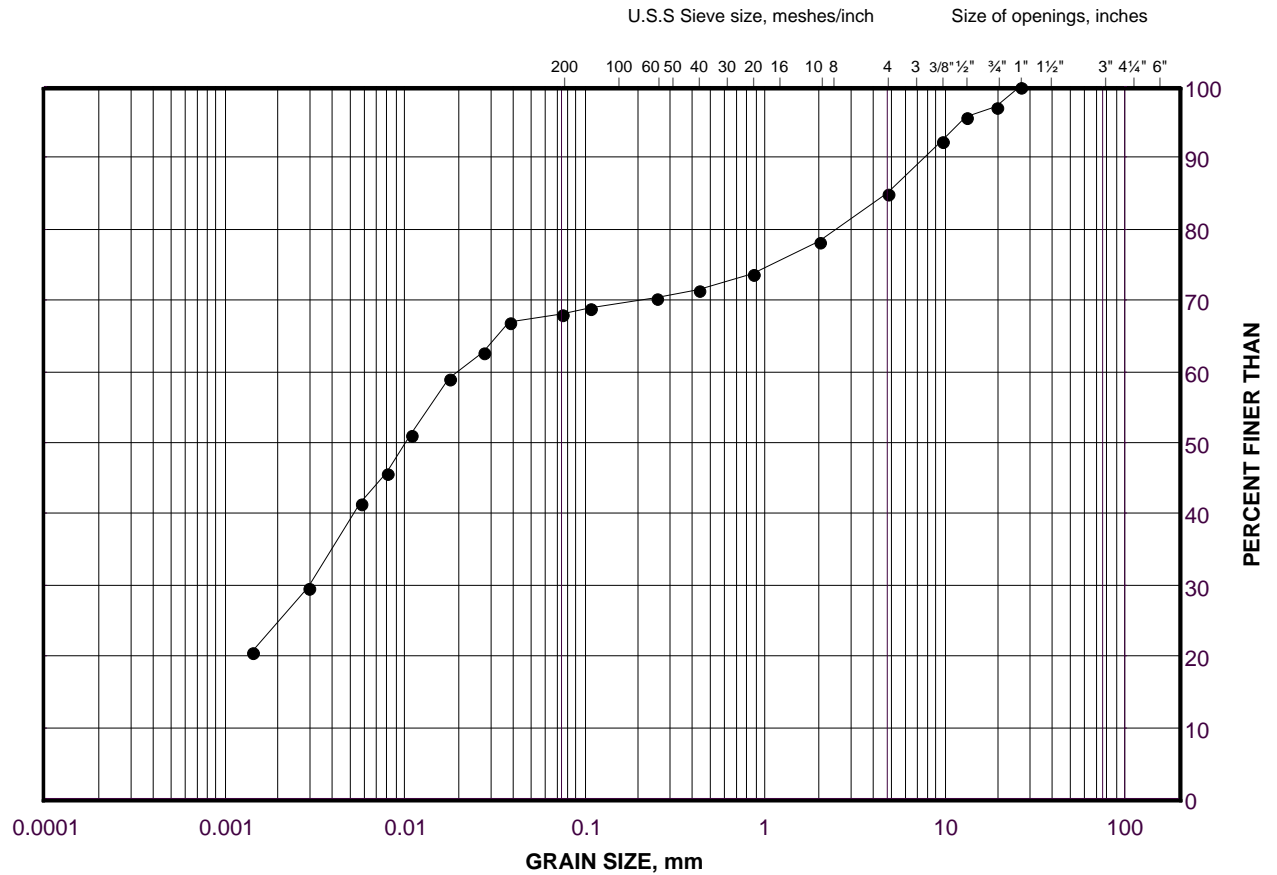
Date: 28-Nov-18



# GRAIN SIZE DISTRIBUTION

Silty Clay (Till)

FIGURE B10



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

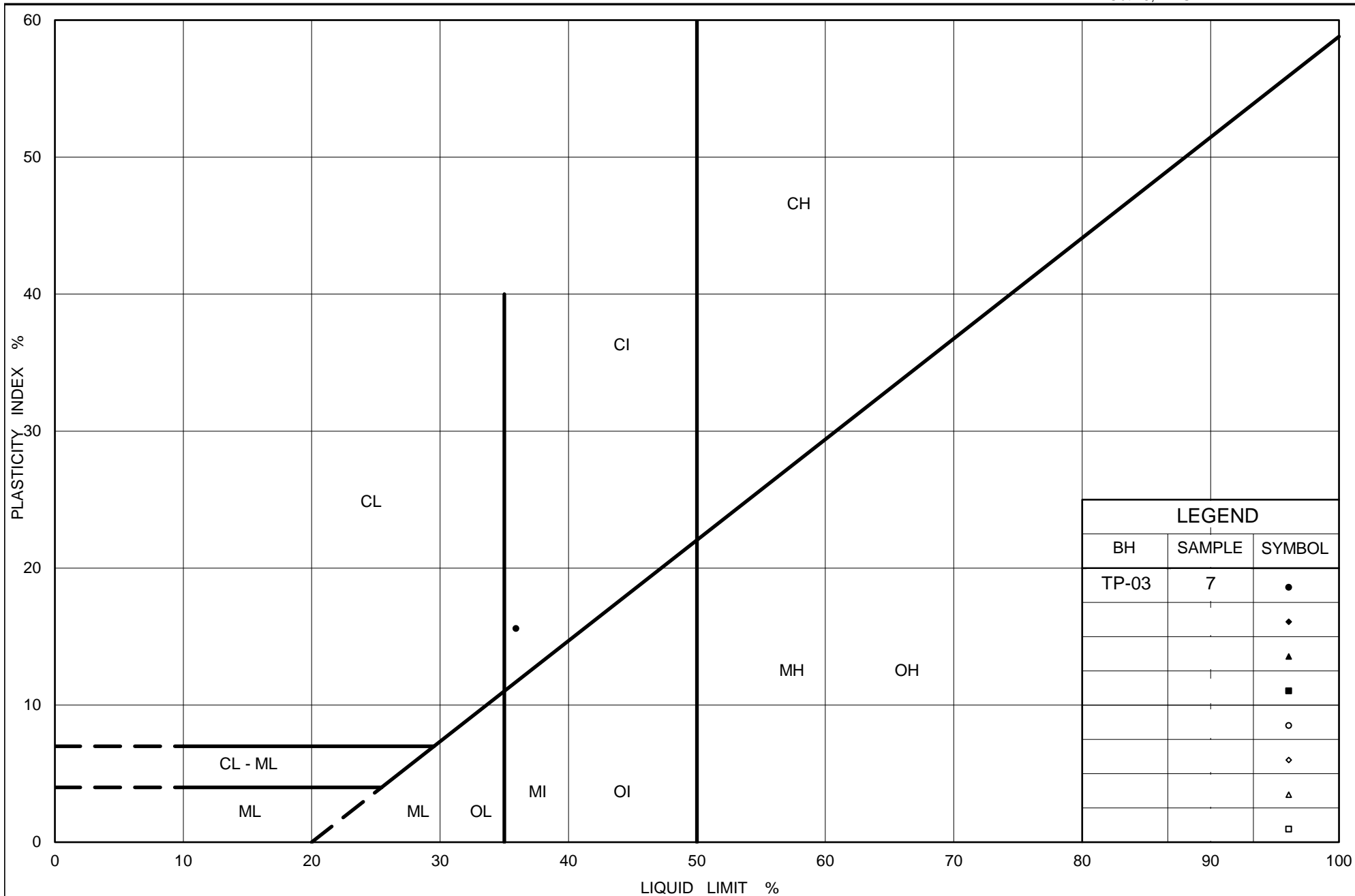
SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
•	TP-03	7	150.9

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## PLASTICITY CHART

### Silty Clay (Till)

Figure No. B11

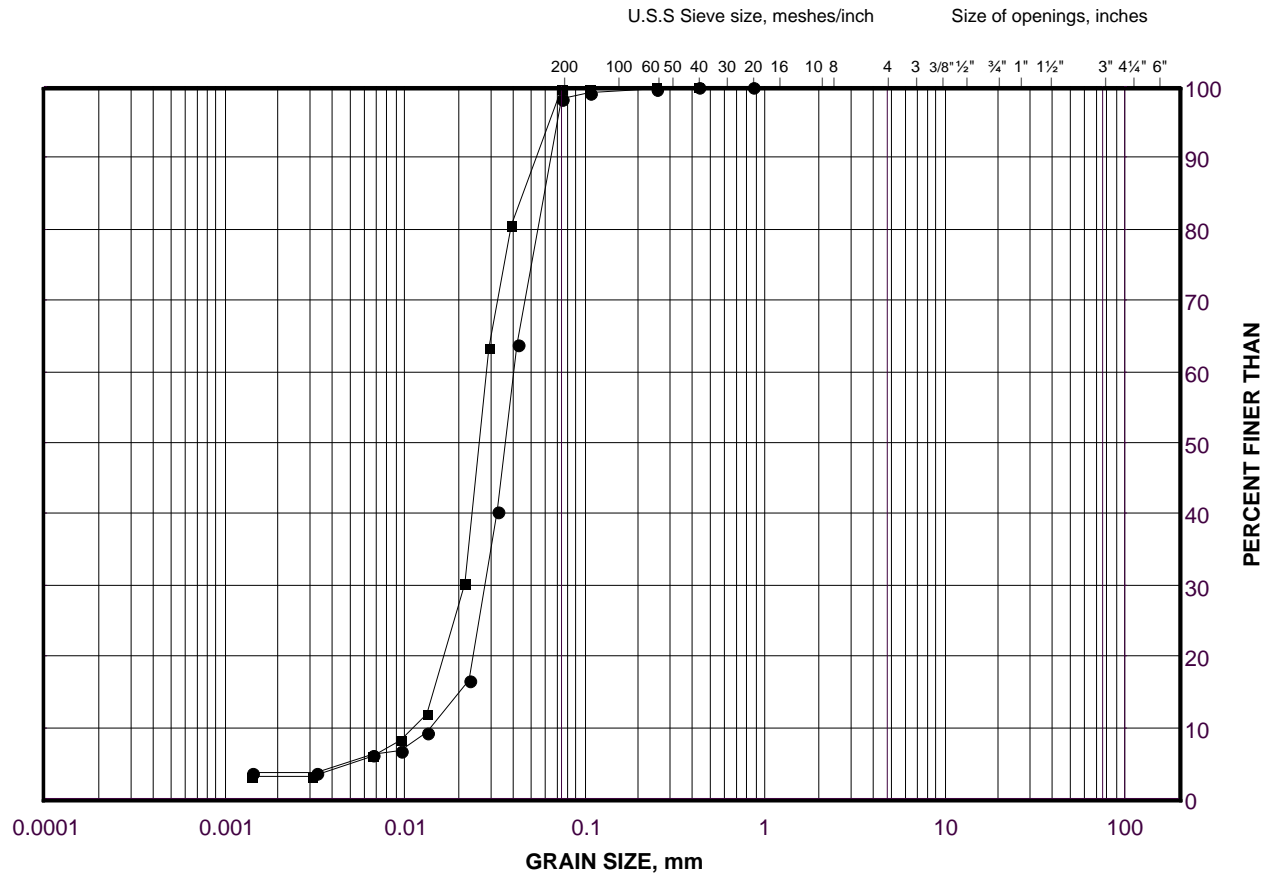
Project No. 1665765

Checked By: NK

# GRAIN SIZE DISTRIBUTION

Silt

FIGURE B12



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
●	TP-05	2	159.9
■	TP-05	5	157.6

Project Number: 1665765

Checked By: NK

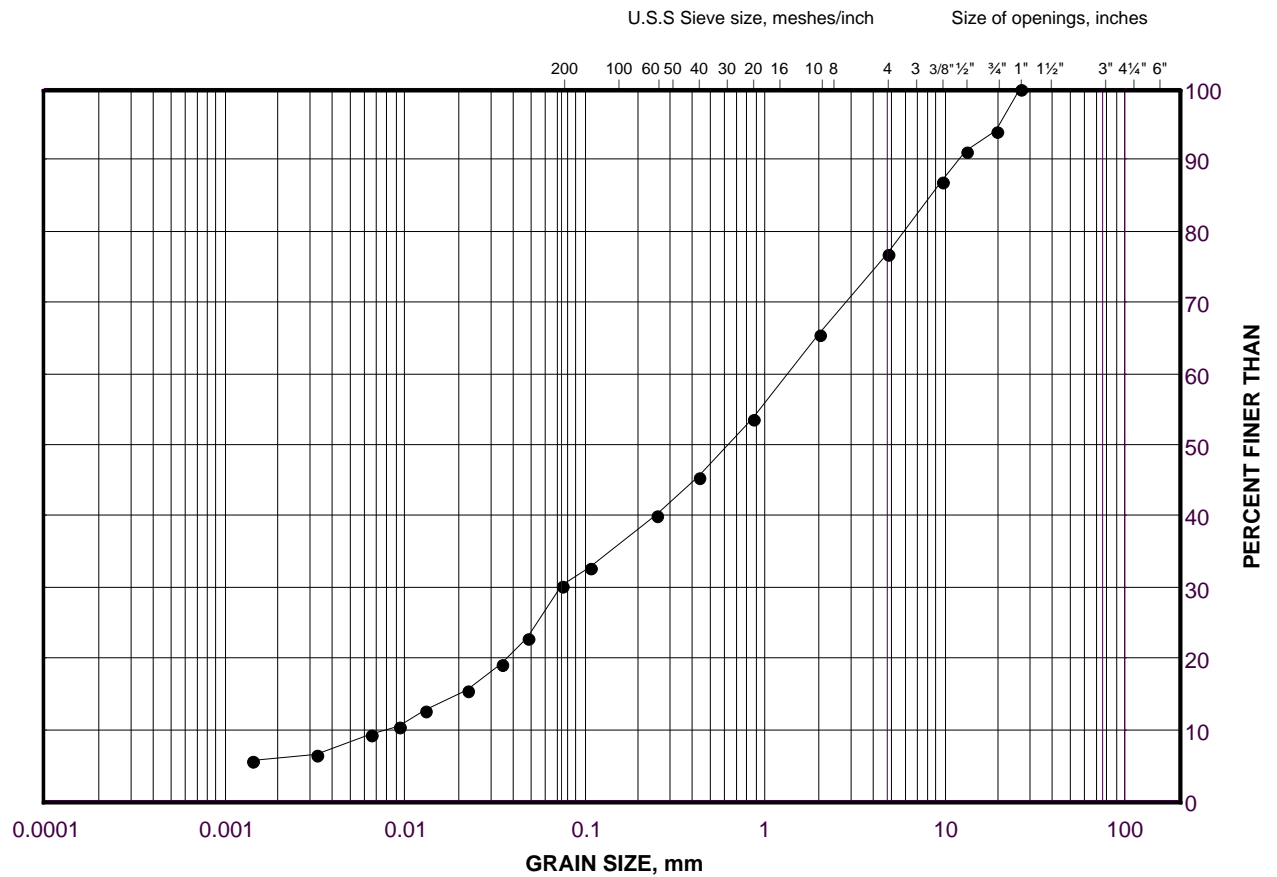
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Date: 16-Jan-19

# GRAIN SIZE DISTRIBUTION

Gravelly Silty Sand

FIGURE B13



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
•	TP-05	7	155.3

Project Number: 1665765

Checked By: NK

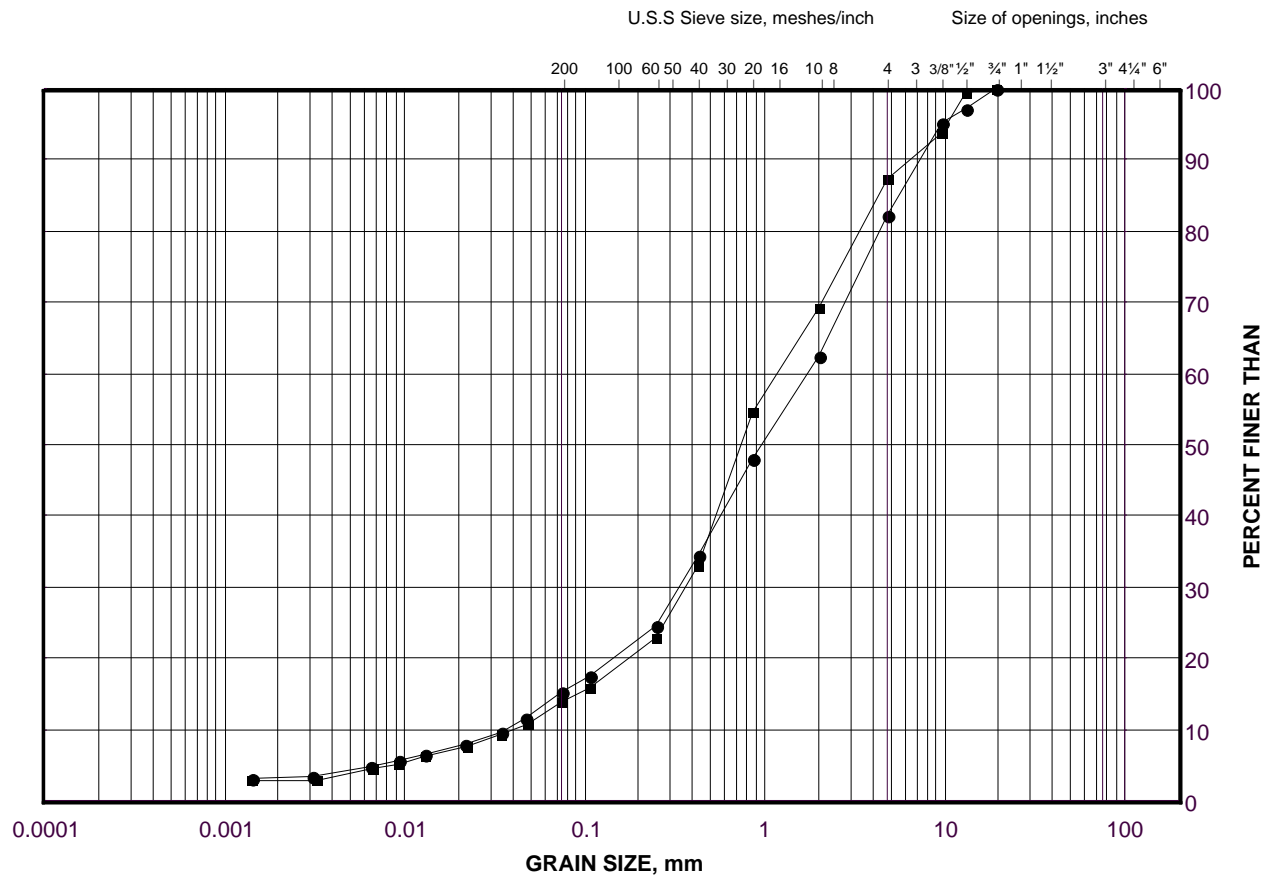
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Date: 16-Jan-19

# GRAIN SIZE DISTRIBUTION

Sand

FIGURE B14



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

## LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
●	TP-06	2	159.6
■	TP-06	6	156.5

Project Number: 1665765

Checked By: NK

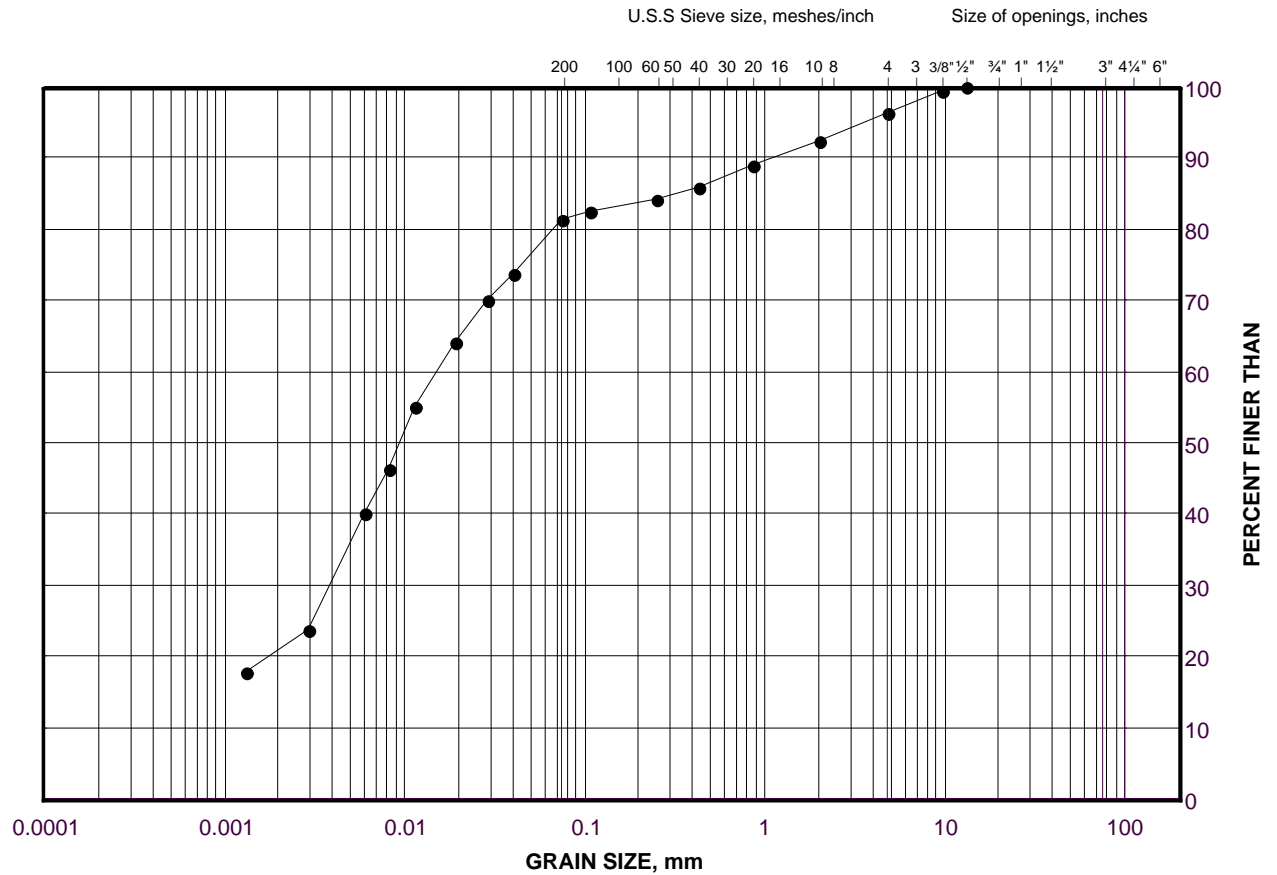
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# GRAIN SIZE DISTRIBUTION

Silty Clay (Till)

FIGURE B15



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

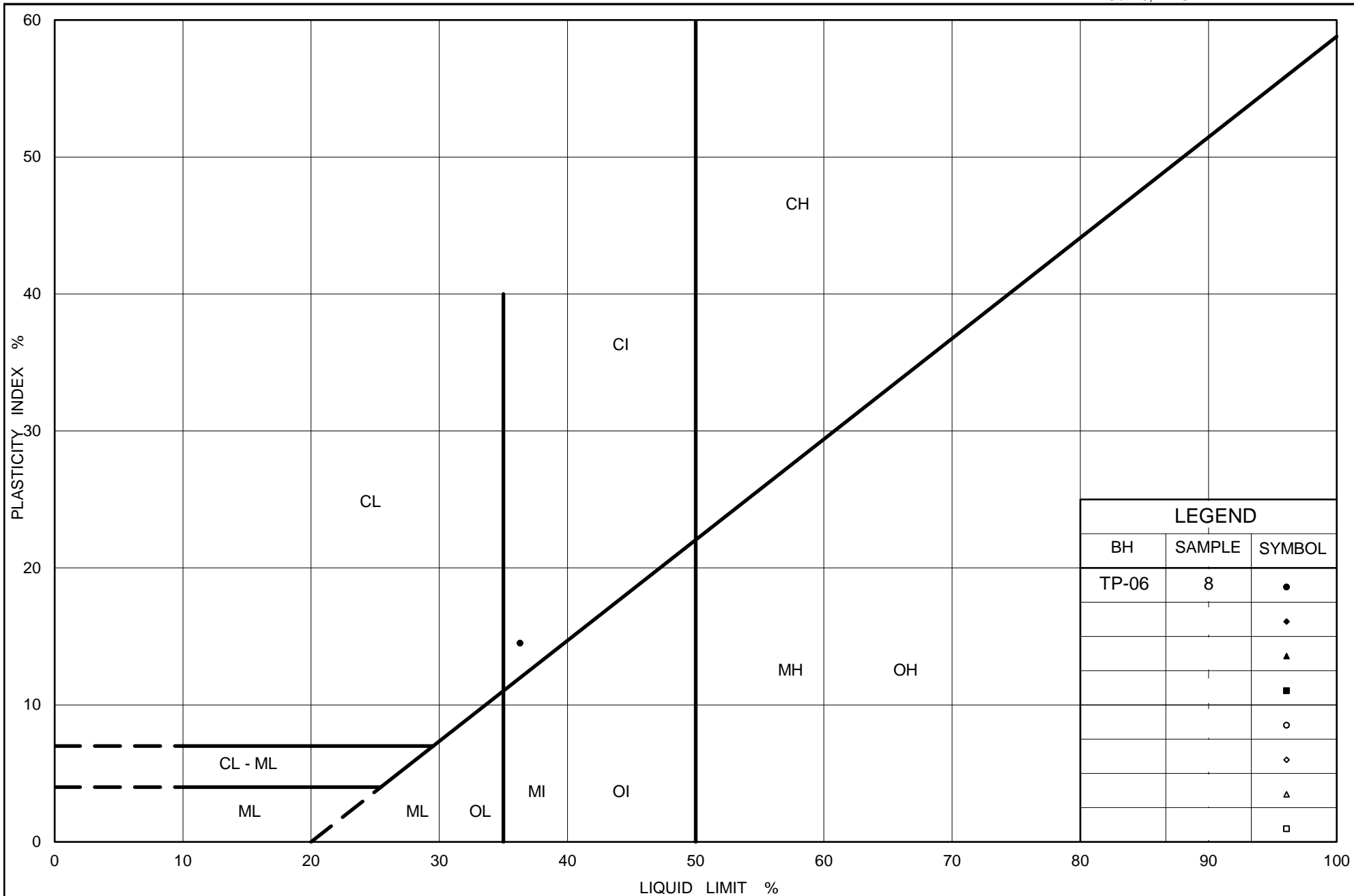
SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
•	TP-06	8	153.5

Project Number: 1665765

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## PLASTICITY CHART

### Silty Clay (Till)

Figure No. B16

Project No. 1665765

Checked By: NK

**APPENDIX C**

# Non-Standard Special Provisions



**PROTECTION SYSTEMS – Item No.**

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Special Provision

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**Amendment to OPSS 539, November 2014**

**539.07.02          Removal of Protection Systems**

Subsection 539.07.02 of OPSS 539 is deleted in its entirety and replaced with the following:

Protection systems may be fully removed or may be left in place, unless otherwise specified.

Where protection systems are left in place, the top (including any and all timber lagging) shall be removed to at least 1.5 m below ground surface and/or to bottom of the pavement structure (i.e., bottom of granular sub-base) or granular drainage layer, whichever is greatest.

The method and sequence of removal shall be such that there shall be no damage to the new work, existing work and facility being protected.

All disturbed areas shall be restored to an equivalent or better condition than existing prior to the commencement of construction.

**OBSTRUCTIONS – Item No.**

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Notice to Contractor

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The Contractor shall be alerted to the presence of obstructions including shale fragments, cobbles and boulders within the fill soils and the native silt to sandy silt to sand, gravelly silty sand to sand and gravel, silty clay and silty clay till deposits. Details of the depths at which obstructions were encountered (as inferred from auger grinding during borehole investigation and/or auger refusal) are detailed in the Foundation Investigation Report and associated Record of Boreholes at each bridge site. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for excavations and installation of temporary protection systems.



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